



# Massachusetts Technical Reference Manual

for Estimating Savings from Energy Efficiency Measures

2022-2024 Plan Version

November 2021

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## Introduction

This *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures* (“TRM”) documents for regulatory agencies, customers, and other stakeholders how the energy efficiency Program Administrators (“PAs”) consistently, reliably, and transparently calculate savings from the installation of efficient equipment, collectively called “measures.” This reference manual provides methods, formulas, and default assumptions for estimating energy, peak demand, and other resource impacts from efficiency measures.

This document is available in an electronic database that allows interested parties to access reports and data in a consistent and easily accessible format. The electronic reports are accessible online via [this link](#)<sup>1</sup>.

Within this document, efficiency measures are organized by the sector for which the measure is eligible and by the primary energy source associated with the measure. The three sectors are Residential, Income Eligible, and Commercial & Industrial (“C&I”). The primary energy sources addressed in this technical reference document are electricity and natural gas.

Each measure is presented in its own section as a “measure characterization.” The measure characterizations provide mathematical equations for determining savings (algorithms), as well as default assumptions and sources, where applicable. In addition, any descriptions of calculation methods or baselines are provided as appropriate. The parameters for calculating savings are listed in the same order for each measure.

Algorithms are provided for estimating annual energy and peak demand impacts for primary and secondary energy sources if appropriate. In addition, algorithms or calculated results may be provided for other non-energy impacts (such as water savings or operation and maintenance cost savings). Data assumptions are based on Massachusetts PA data where available. Where Massachusetts-specific data is not available, assumptions may be based on: 1) manufacturer and industry data, 2) a combination of the best available data from jurisdictions in the same region, or 3) credible and realistic factors developed using engineering judgment.

This document will be reviewed and updated annually to reflect changes in technology, baselines, and evaluation results.

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<sup>1</sup> <https://etrm.anbetrack.com/#/workarea/home?token=6d6c45766e692f527044>

## TRM Update Process

### Overview

This section describes the process for updating this document. The update process is synchronized with the filing of Three-Year Plans and Plan-Year/Term Reports by the PAs with the Department of Public Utilities (“Department”).

Updates can include:

- additions of new measures;
- updates to existing measures due to:
  - changes in baseline equipment or practices, affecting measure savings
  - changes in efficient equipment or practices, affecting measure savings
  - changes to deemed savings due the revised assumptions for algorithm parameter values (e.g., due to new market research or evaluation studies)
  - other similar types of changes;
- updates to impact factors (e.g., due to new impact evaluation studies);
- discontinuance of existing measures; and
- updates to the glossary and other background material included in this document.

Each report edition is associated with a specific program year, which corresponds to the calendar year. This document is updated over time as needed to plan for future program savings.

### Key Stakeholders and Responsibilities

Key stakeholders and their responsibilities for the TRM updates are detailed in the following table.

| Stakeholder                    | Responsibilities                                                                                                                                                                                                                                                                       |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Coordinating Committee         | Administrative coordination of activities, including:<br>Assure collaboration and consensus by the PAs regarding updates<br>Assure updates are compiled from the PAs and incorporated<br>Coordinate with related program activities (e.g., evaluation and program reporting processes) |
| Program Administrators         | Provide one or two representatives to the Coordinating Committee. Both the planning and evaluation functions should be represented on the Committee.<br>Identify needed updates<br>Coordinate with other PAs on all updates<br>File updates with the Department                        |
| Department of Energy Resources | Provide one representative to the Coordinating Committee<br>Assure coordination with PA submissions of program plans and reported savings                                                                                                                                              |

## Update Cycle

Per the Department, starting in 2022, new evaluation results will be applied on a prospective only basis instead of being applied both retrospectively and prospectively. The PAs will update gross savings assumptions and net and gross impact factors each year based on the latest evaluation studies and apply them on a prospective basis to calculate savings in subsequent years. At the beginning of each year, the latest TRM will be posted on Mass Save Data at this [link](#).<sup>2</sup>

## Measure Characterization Structure

This section describes the common entries or inputs that make up each measure characterization. A formatted template follows the descriptions of each section of the measure characterization. A single device or behavior is defined as a measure within each program and fuel.

The source of each assumption or default parameter value should be properly referenced.

The image below shows how a measure appears in this document and in the electronic report format. Each section of this measure report is described in more detail below.

| <b>Refrigerator Replacement - IE Single Family</b><br><b>Measure Code</b> IE-A-RR-SF<br><b>Market</b> Income Eligible<br><b>Program Type</b> Retrofit<br><b>Category</b> Appliances<br><b>Sub Category</b> Appliances<br><b>TRM Version</b> 2019-2021 Plan TRM<br><b>Version</b> 1<br><b>Published On</b> 10/26/2018 10:13:07 PM<br><b>Description :</b><br>Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.<br><b>BCR Measure IDs :</b> |                                              |                |                    |                      |                   |                     | <b>Impact Factors for Calculating Adjusted Gross Savings :</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|----------------|--------------------|----------------------|-------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------|------------------------------------------|----------------------------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-------|-----|--------------|-----------------|-----|--------------------|--------------------------------------------------------------------------------------------------------------------|-------------------|---------------------|------------------------------------------|-----------------------|------------------------------------------|-------|------|---------|------|--------------|--------|------------------------------------------|-------|-----|------|------|-----|------|------|------|------|
| <table border="1"> <thead> <tr> <th>Measure Name</th> <th>Core Initiative</th> <th>BCR Measure ID</th> </tr> </thead> <tbody> <tr> <td>Refrigerator Replacement (Single Family)</td> <td>Income Eligible Coordinated Delivery (IE_CD)</td> <td>E19B1a038</td> </tr> </tbody> </table>                                                                                                                                                                                                                      |                                              |                |                    |                      |                   |                     | Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Core Initiative       | BCR Measure ID | Refrigerator Replacement (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | E19B1a038 | <table border="1"> <thead> <tr> <th>Measure Name</th> <th>Core Initiative</th> <th>PA</th> <th>ISR</th> <th>RRE</th> <th>RRNE</th> <th>RRSP</th> <th>RRWP</th> <th>CFSP</th> <th>CFWP</th> </tr> </thead> <tbody> <tr> <td>Refrigerator Replacement (Single Family)</td> <td>IE_CD</td> <td>All</td> <td>1.00</td> <td>1.00</td> <td>n/a</td> <td>1.00</td> <td>1.00</td> <td>0.79</td> <td>0.65</td> </tr> </tbody> </table> |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   | Measure Name        | Core Initiative                          | PA                    | ISR                                      | RRE   | RRNE | RRSP    | RRWP | CFSP         | CFWP   | Refrigerator Replacement (Single Family) | IE_CD | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | 0.79 | 0.65 |
| Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Initiative                              | BCR Measure ID |                    |                      |                   |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Refrigerator Replacement (Single Family)                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Income Eligible Coordinated Delivery (IE_CD) | E19B1a038      |                    |                      |                   |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Initiative                              | PA             | ISR                | RRE                  | RRNE              | RRSP                | RRWP                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | CFSP                  | CFWP           |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Refrigerator Replacement (Single Family)                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | IE_CD                                        | All            | 1.00               | 1.00                 | n/a               | 1.00                | 1.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0.79                  | 0.65           |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| <b>Algorithms for Calculating Primary Energy Impact :</b><br>Unit savings are deemed based on study results. <sup>1</sup> kWh savings are derived from the Navigant Demand Impact Model. <sup>2</sup>                                                                                                                                                                                                                                                                                                      |                                              |                |                    |                      |                   |                     | <b>In-Service Rates:</b><br>All installations have 100% in service rate since all PA programs include verification of equipment installations.<br><b>Realization Rates:</b><br>Realization rates are set to 100% since this measure has not been evaluated.<br><b>Coincidence Factors:</b><br>Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Navigant Demand Impact Model.                                                        |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| <table border="1"> <thead> <tr> <th>Measure</th> <th>kWh</th> <th>kW</th> </tr> </thead> <tbody> <tr> <td>Refrigerator Replacement (Single Family)</td> <td>762</td> <td>0.13</td> </tr> </tbody> </table>                                                                                                                                                                                                                                                                                                 |                                              |                |                    |                      |                   |                     | Measure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | kWh                   | kW             | Refrigerator Replacement (Single Family) | 762                                          | 0.13      | <b>Impact Factors for Calculating Net Savings :</b>                                                                                                                                                                                                                                                                                                                                                                           |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Measure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | kWh                                          | kW             |                    |                      |                   |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Refrigerator Replacement (Single Family)                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 762                                          | 0.13           |                    |                      |                   |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| <b>Baseline Efficiency :</b><br>The baseline efficiency case for both the replaced and baseline new refrigerator is an existing refrigerator. It is assumed that low-income customers would otherwise replace their refrigerators with a used inefficient unit.<br><b>High Efficiency :</b><br>The high efficiency case is a new refrigerator.<br><b>Measure Life :</b><br>The measure life is 12 years. <sup>3</sup>                                                                                      |                                              |                |                    |                      |                   |                     | <table border="1"> <thead> <tr> <th>Measure Name</th> <th>Core Initiative</th> <th>PA</th> <th>FR</th> <th>SO<sub>p</sub></th> <th>SO<sub>NP</sub></th> <th>NTG</th> </tr> </thead> <tbody> <tr> <td>Refrigerator Replacement (Single Family)</td> <td>IE_CD</td> <td>All</td> <td>0%</td> <td>0%</td> <td>0%</td> <td>100%</td> </tr> </tbody> </table>                                                                                                                                        |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     | Measure Name | Core Initiative | PA  | FR                 | SO <sub>p</sub>                                                                                                    | SO <sub>NP</sub>  | NTG                 | Refrigerator Replacement (Single Family) | IE_CD                 | All                                      | 0%    | 0%   | 0%      | 100% |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Initiative                              | PA             | FR                 | SO <sub>p</sub>      | SO <sub>NP</sub>  | NTG                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Refrigerator Replacement (Single Family)                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | IE_CD                                        | All            | 0%                 | 0%                   | 0%                | 100%                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| <table border="1"> <thead> <tr> <th>Measure Name</th> <th>Core Initiative</th> <th>PA</th> <th>EUL</th> <th>OYF</th> <th>RUL</th> <th>AML</th> </tr> </thead> <tbody> <tr> <td>Refrigerator Replacement (Single Family)</td> <td>IE_CD</td> <td>All</td> <td>12</td> <td>n/a</td> <td>n/a</td> <td>12</td> </tr> </tbody> </table>                                                                                                                                                                         |                                              |                |                    |                      |                   |                     | Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Core Initiative       | PA             | EUL                                      | OYF                                          | RUL       | AML                                                                                                                                                                                                                                                                                                                                                                                                                           | Refrigerator Replacement (Single Family) | IE_CD | All | 12           | n/a             | n/a | 12                 | <b>Non-Energy Impacts :</b><br>NEI values are rolled up, component values can be found in Appendix B. <sup>4</sup> |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Initiative                              | PA             | EUL                | OYF                  | RUL               | AML                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Refrigerator Replacement (Single Family)                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | IE_CD                                        | All            | 12                 | n/a                  | n/a               | 12                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| <b>Other Resource Impacts :</b><br>There are no other resource impacts for this measure.                                                                                                                                                                                                                                                                                                                                                                                                                   |                                              |                |                    |                      |                   |                     | <table border="1"> <thead> <tr> <th>Measure Name</th> <th>Core Initiative</th> <th>PA</th> <th>Annual \$ per Unit</th> <th>One-time \$ per Unit</th> <th>Annual \$ per kWh</th> <th>One-time \$ per kWh</th> <th>Annual \$ per Therm</th> <th>One-time \$ per Therm</th> </tr> </thead> <tbody> <tr> <td>Refrigerator Replacement (Single Family)</td> <td>IE_CD</td> <td>All</td> <td>\$20.10</td> <td></td> <td>Varies by PA</td> <td>\$0.01</td> <td></td> <td></td> </tr> </tbody> </table> |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     | Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit                                                                                               | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm                      | One-time \$ per Therm | Refrigerator Replacement (Single Family) | IE_CD | All  | \$20.10 |      | Varies by PA | \$0.01 |                                          |       |     |      |      |     |      |      |      |      |
| Measure Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Core Initiative                              | PA             | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | One-time \$ per Therm |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| Refrigerator Replacement (Single Family)                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | IE_CD                                        | All            | \$20.10            |                      | Varies by PA      | \$0.01              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |
| <b>Endnotes :</b><br>1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation.<br>2 : Navigant Consulting (2018). Demand Impact Model Update.<br>3 : Environmental Protection Agency (2014). Savings Calculator for Energy Star Qualified Appliances.                                                                                                                                                                                                                                 |                                              |                |                    |                      |                   |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                |                                          |                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |     |              |                 |     |                    |                                                                                                                    |                   |                     |                                          |                       |                                          |       |      |         |      |              |        |                                          |       |     |      |      |     |      |      |      |      |

## Measure Summary

This section includes a high-level categorization of the energy efficiency measure:

<sup>2</sup> <https://www.masssavedata.com/Public/TechnicalReferenceLibrary>

**Measure Code:** A unique way to identify a measure where the first set of characters indicates the market, the second set of characters indicates the category, and the third set is an abbreviated code for the measure name.

**Market:** This is the sector for which the measure is applicable and can be Residential, Income Eligible or C&I.

**Program Type, Category, and Sub-Category:** A way of categorizing similar measures.

**TRM Version and Version:** Indicates that information is for the 2022-2024 TRM and allows for differentiation between versions for potential future updates.

**Published On:** Date that the measure was published.

## 01: Description

This section will include a plain text description of the energy efficiency measure, including the benefit(s) of its installation.

## 02: BCR Measure IDs

This section provides an overview of all individual measures to which the TRM entry applies, including:

**BCR Measure Name:** <Name used in PAs Benefit-Cost models >

**Core Initiative:** <Per PA definition, also referred to as Program Name>

**BCR Measure ID:** <Unique ID used in PAs Benefit-Cost models>

## 03: Algorithms for Calculating Primary Energy Impact

This section will describe the method for calculating electric savings and electric demand savings in appropriate units.

The savings algorithm will be provided in a form similar to the following:

$$\Delta kWh = \Delta kW \times Hours$$

Similarly, the method for calculating electric demand savings will be provided in a form similar to the following:

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

This section also describes any non-electric (gas, propane, oil) savings in appropriate units, i.e., MMBtu associated with the energy efficiency measure, including all assumptions and the method of calculation.

This section will summarize electric and non-electric savings in a table that contains the following information:

**BCR Measure Name:** <Name used in PAs Benefit-Cost models >

**Core Initiative:** <Per PA definition, also referred to as Program Name>

**Savings:** <Measure savings in units of kWh, kW, MMBtu, or other as applicable; this information may be contained in multiple fields>

## 04: Baseline Efficiency

This section will include a statement of the assumed equipment/operation efficiency in the absence of program intervention. Multiple baselines will be provided as needed, e.g., for different markets. Baselines may refer to reference tables or may be presented as a table for more complex measures.

**05: High Efficiency**

This section will describe the high efficiency case from which the energy and demand savings are determined. The high efficiency case may be based on specific details of the measure installation, minimum requirements for inclusion in the program, or an energy efficiency case based on historical participation. It may refer to tables within the measure characterization or in the appendices or efficiency standards set by organizations such as ENERGY STAR® and the Consortium for Energy Efficiency.

**06: Measure Life**

Measure Life includes equipment life, and the effects of measure persistence. Equipment life is the number of years that a measure is installed and will operate until failure. Measure persistence takes into account business turnover, early retirement of installed equipment, and other reasons measures might be removed or discontinued. As applicable, this section may include a table with the following information:

- EUL:** <Effective Useful Life>
- OYF:** <Out Year Factor>
- RUL:** <Remaining Useful Life>
- AML:** <Adjusted Measure Life>

**07: Other Resource Impacts**

If applicable, this section describes any water savings associated with the energy efficiency measure, including all assumptions.

**08: Impact Factors for Calculating Adjusted Gross Savings**

The section includes a table of impact factor values for calculating adjusted gross savings. These include in-service rates, realization rates, and coincidence factors. Further descriptions of the impact factors and the sources on which they are based are described below.

**09: Impact Factors for Calculating Net Savings**

This section includes a table of impact factors for calculating net savings. These includes free ridership, spillover, and/or net-to-gross ratio. Further descriptions of the impact factors and the sources on which they are based are described below.

**Initiative/Program Names**

The mapping of full core initiative names to abbreviated names is given below.

| Sector      | Full Core Initiative Name                 | Abbreviation |
|-------------|-------------------------------------------|--------------|
| Residential | A1a - Residential New Homes & Renovations | RES_NH&R     |
|             | A2a - Residential Coordinated Delivery    | RES_CD       |

|                 |                                              |            |
|-----------------|----------------------------------------------|------------|
|                 | A2c - Residential Retail                     | RES_RETAIL |
|                 | A2d - Residential Behavior                   | RES_BEHVR  |
|                 | A2e - Residential Active Demand Reduction    | RES_ADR    |
| Income Eligible | B1a - Income Eligible Coordinated Delivery   | IE_CD      |
|                 | B1b -Income Eligible Active Demand Reduction | IE_ADR     |
| C&I             | C1a - C&I New Buildings & Major Renovations  | CI_NB&MR   |
|                 | C2a - C&I Existing Building Retrofit         | CI_RETRO   |
|                 | C2b - C&I New & Replacement Equipment        | CI_EQUIP   |
|                 | C2c - C&I Active Demand Reduction            | CI_ADR     |

## Impact Factors for Calculating Adjusted Gross and Net Savings

PAs use the algorithms in the Measure Characterization sections to calculate the gross savings for energy efficiency measures. Impact factors are then applied to make various adjustments to the gross savings estimate to account for the performance of individual measures or energy efficiency programs as a whole in achieving energy reductions as assessed through evaluation studies. Impact factors address both the technical performance of energy efficiency measures and programs, accounting for the measured energy and demand reductions realized compared to the gross estimated reductions, as well as the programs' effect on the market for energy efficient products and services.

This section describes the types of impact factors used to make such adjustments, and how those impacts are applied to gross savings estimates. Definitions of the impact factors and other terms are also provided in Appendix D: Glossary.

### Types of Impact Factors

The impact factors used to adjust savings fall into one of two categories:

Impact factors used to adjust gross savings:

- In-Service Rate (“ISR”)
- Savings Persistence Factor (“SPF”)
- Realization Rate (“RR”)
- Summer and Winter Peak Demand Coincidence Factors (“CF”)

Impact factors used to calculate net savings:

- Free-Ridership (“FR”) and Spillover (“SO”) Rates
- Net-to-Gross Ratios (“NTG”)

The **in-service rate** is the actual portion of efficient units that are installed. For example, efficient lamps may have an in-service rate less than 1.00 since some lamps are purchased as replacement units and are not immediately installed. The ISR is 1.00 for most measures.

The **savings persistence factor** is the portion of first-year energy or demand savings expected to persist over the life of the energy efficiency measure. The SPF is developed by conducting surveys of installed equipment several years after installation to determine the actual operational capability of the equipment. The SPF is 1.00 for most measures.

In contrast to savings persistence, *measure persistence* takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor.

The **realization rate** is used to adjust the gross savings (as calculated by the savings algorithms) based on impact evaluation studies. The realization rate is equal to the ratio of measure savings developed from an impact evaluation to the estimated measure savings derived from the savings algorithms. The realization rate does not include the effects of any other impact factors. Depending on the impact evaluation study,

there may be separate Realization Rates for electric energy (kWh), peak demand (kW), or non-electric energy (MMBtu).

A **coincidence factor** adjusts the connected load kW savings derived from the savings algorithm. A coincidence factor represents the fraction of the connected load reduction expected to occur at the same time as a particular system peak period. The coincidence factor includes both coincidence and diversity factors combined into one number, thus there is no need for a separate diversity factor in this TRM.

Coincidence Factors are provided for both the on-peak and seasonal peak periods as defined by the ISO New England for the Forward Capacity Market (“FCM”) and are calculated consistently with the FCM methodology. Electric demand reduction during the ISO New England peak periods is defined as follows:

**On-Peak Definition:**

- **Summer On-Peak:** average demand reduction from 1:00-5:00 PM on non-holiday weekdays in June, July, and August
- **Winter On-Peak:** average demand reduction from 5:00-7:00 PM on non-holiday weekdays in December and January

**Seasonal Peak Definition:**

- **Summer Seasonal Peak:** demand reduction when the real-time system hourly load is equal to or greater than 90% of the most recent “50/50” system peak forecast for June-August
- **Winter Seasonal Peak:** demand reduction when the real-time system hourly load is equal to or greater than 90% of the most recent “50/50” system peak load forecast for December-January

The values described as Coincidence Factors in the TRM are not always consistent with the strict definition of a Coincidence Factor (CF). It would be more accurate to define the Coincidence Factor as “the value that is multiplied by the Gross kW value to calculate the average kW reduction coincident with the peak periods.” A coincidence factor of 1.00 may be used because the coincidence is already included in the estimate of Gross kW; this is often the case when the “Max kW Reduction” is not calculated and instead the “Gross kW” is estimated using the annual kWh reduction estimate and a loadshape model.

A **free-rider** is a customer who participates in an energy efficiency program (and gets an incentive) but who would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available. The **free-ridership rate** is the percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.

The **spillover rate** is the percentage of savings attributable to a measure or program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of 1) participants in the program who install additional energy efficient measures outside of the program as a result of participating in the program, and 2) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program. These two components are the **participant spillover** (SO<sub>P</sub>) and **non-participant spillover** (SO<sub>NP</sub>).

The **net savings** value is the final value of savings that is attributable to a measure or program. Net savings differs from gross savings because it includes the effects of the free-ridership and/or spillover rates.

The **net-to-gross** ratio is the ratio of net savings to the gross savings adjusted by any impact factors (i.e., the “adjusted” gross savings). Depending on the evaluation study, the NTG ratio may be determined from the free-ridership and spillover rates, if available, or it may be a distinct value with no separate specification of FR and SO values.



## Standard Net-to-Gross Formulas

The TRM measure entries provide algorithms for calculating the gross savings for those efficiency measures. The following standard formulas show how the impact factors are applied to calculate the adjusted gross savings, which in turn are used to calculate the net savings. These are the calculations used by the PAs to track and report gross and net savings. The gross savings reported by the PAs are the unadjusted gross savings without the application of any impact factors.

### Calculation of Net Annual Electric Energy Savings

$$\begin{aligned} \text{adj\_gross\_kWh} &= \text{gross\_kWh} \times \text{RR}_E \times \text{SPF} \times \text{ISR} \\ \text{net\_kWh} &= \text{adj\_gross\_kWh} \times \text{NTG} \end{aligned}$$

### Calculation of Net Summer Electric Peak Demand Coincident kW Savings

$$\begin{aligned} \text{adj\_gross\_kW}_{\text{SP}} &= \text{gross\_kW} \times \text{RR}_{\text{SP}} \times \text{SPF} \times \text{ISR} \times \text{CF}_{\text{SP}} \\ \text{net\_kW}_{\text{SP}} &= \text{adj\_gross\_kW}_{\text{SP}} \times \text{NTG} \end{aligned}$$

### Calculation of Net Winter Electric Peak Demand Coincident kW Savings

$$\begin{aligned} \text{adj\_gross\_kW}_{\text{WP}} &= \text{gross\_kW} \times \text{RR}_{\text{WP}} \times \text{SPF} \times \text{ISR} \times \text{CF}_{\text{WP}} \\ \text{net\_kW}_{\text{WP}} &= \text{adj\_gross\_kW}_{\text{WP}} \times \text{NTG} \end{aligned}$$

### Calculation of Net Annual Natural Gas Energy Savings

$$\begin{aligned} \text{adj\_gross\_MMBtu} &= \text{gross\_MMBtu} \times \text{RR}_{\text{NE}} \times \text{SPF} \times \text{ISR} \\ \text{net\_MMBtu} &= \text{adj\_gross\_MMBtu} \times \text{NTG} \end{aligned}$$

Depending on the evaluation study methodology:

- NTG is equal to  $(1 - \text{FR} + \text{SO}_P + \text{SO}_{\text{NP}})$ , or
- NTG is a single value with no distinction of FR,  $\text{SO}_P$ ,  $\text{SO}_{\text{NP}}$ , and/or other factors that cannot be reliably isolated.

Where:

|                            |   |                                                   |
|----------------------------|---|---------------------------------------------------|
| Gross_kWh                  | = | Gross Annual kWh Savings                          |
| adj_gross_kWh              | = | Adjusted Gross Annual kWh Savings                 |
| net_kWh                    | = | Net Annual kWh Savings                            |
| Gross_kW <sub>SP</sub>     | = | Gross Connected kW Savings (summer peak)          |
| adj_gross_kW <sub>SP</sub> | = | Adjusted Gross Connected kW Savings (summer peak) |
| Gross_kW <sub>WP</sub>     | = | Gross Connected kW Savings (winter peak)          |
| adj_gross_kW <sub>WP</sub> | = | Adjusted Gross Connected kW Savings (summer peak) |
| net_kW <sub>SP</sub>       | = | Adjusted Gross Connected kW Savings (winter peak) |

|                      |   |                                         |
|----------------------|---|-----------------------------------------|
| net_kW <sub>WP</sub> | = | Net Coincident kW Savings (winter peak) |
| Gross_MMBtu          | = | Gross Annual MMBtu Savings              |
| adj_gross_MMBtu      | = | Adjusted Gross Annual MMBtu Savings     |
| net_MMBtu            | = | Net Annual MMBtu Savings                |
| SPF                  | = | Savings Persistence Factor              |
| ISR                  | = | In-Service Rate                         |
| CF <sub>SP</sub>     | = | Peak Coincidence Factor (summer peak)   |
| CF <sub>WP</sub>     | = | Peak Coincidence Factor (winter peak)   |
| RR <sub>E</sub>      | = | Realization Rate, electric(kWh)         |
| RR <sub>NE</sub>     | = | Realization Rate, non-electric (MMBtu)  |
| RR <sub>SP</sub>     | = | Realization Rate for summer peak kW     |
| RR <sub>WP</sub>     | = | Realization Rate for winter peak kW     |
| NTG                  | = | Net-to-Gross Ratio                      |
| FR                   | = | Free-Ridership Factor                   |
| SO <sub>P</sub>      | = | Participant Spillover Factor            |
| SO <sub>NP</sub>     | = | Non-Participant Spillover Factor        |

### Calculations of Coincident Peak Demand kW Using “Seasonal Peak” Coincidence Factors

The formulas above for peak demand kW savings use the “on-peak” Coincidence Factors: (CF<sub>SP</sub>, CF<sub>WP</sub>), which apply the “on-peak” coincidence methodology as allowed for submission to the FCM. The alternative methodology is the “seasonal peak” methodology, which uses the identical formulas, but substituting the “seasonal peak” Coincidence Factors for the “on-peak” coincidence factors:

|                   |   |                                                  |
|-------------------|---|--------------------------------------------------|
| CF <sub>SSP</sub> | = | Peak Coincidence Factor for Summer Seasonal Peak |
| CF <sub>WSP</sub> | = | Peak Coincidence Factor for Winter Seasonal Peak |

# 1. Residential Efficiency Measures

## 1.1. Appliance - Clothes Dryer

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-A-CD    |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Appliances  |

### Measure Description:

Clothes Dryers exceeding minimum qualifying efficiency standards established as ENERGY STAR with drum moisture sensors and associated moisture sensing controls achieve greater energy savings over clothes dryers that do not have moisture sensors.

### BCR Measure IDs:

| Measure                     | Core Initiative                 | BCR Measure ID |
|-----------------------------|---------------------------------|----------------|
| Clothes Dryer (Energy Star) | Residential Retail (RES_RETAIL) | EA2c077        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:

Annual kWh Savings = Annual kWh usage baseline – Annual kWh usage Energy Star

Annual kWh usage baseline= (lbs/load) / Baseline CEF \* loads/yr

Annual kWh usage ENERGY STAR= (lbs/load) / ENERGY STAR CEF \* loads/yr

Where:

Baseline Combined Energy Factor (CEF) (lbs/kWh) = 3.11<sup>1</sup>

ENERGY STAR CEF = 3.93<sup>2</sup>

Lbs/load = 8.45<sup>3</sup>

Loads/Year = 283<sup>4</sup>

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>5</sup>

| Measure Name        | ΔkWh | ΔkW  |
|---------------------|------|------|
| Dryer (Energy Star) | 160  | 0.05 |

### Baseline Efficiency:

The baseline efficiency case is a new electric resistance dryer that meets the federal standard as of January 1, 2015 which is an Energy Factor (EF) of 3.73 for a vented standard dryer. Different testing procedures were

used in setting the federal standard (DOE Test Procedure Appendix D1) and the Energy Star standard (DOE Test Procedure Appendix D2). To enable comparison a baseline CEF of 3.11 is used. This was derived from ENERGY STAR Version 1.0 Estimated Baseline which multiplies the 2015 federal standard by the average change in electric dryers assessed CEF between Appendix D1 and Appendix D2:  $3.73 - (3.73 * 0.166)$ .

**High Efficiency:**

The high efficiency case is a new electric resistance dryer that meets the Energy Star standard as of January 1, 2015. The ENERGY STAR CEF (Combined Energy Factor) is 3.93.

**Measure Life:**

The measure life is 16 years.<sup>6</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Dryer (Energy Star) | RES_RETAIL      | All | 16  | n/a | n/a | 16  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Dryer (Energy Star) | RES_RETAIL      | All | 0.99 | 1.00            | n/a              | 1.00             | 1.00             | 0.17             | 0.39             |

**In-Service Rates:**

The in-service rate is 99% based on evaluation results.<sup>7</sup>

**Realization Rates:**

Realization rates are based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>8</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are based on evaluation results.<sup>9</sup>

**2022**

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------|-----------------|-----|------|-----------------|------------------|------|
| Dryer (Energy Star) | RES_RETAIL      | All | 0.47 | 0.00            | 0.00             | 0.53 |

**2023**

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------|-----------------|-----|------|-----------------|------------------|------|
| Dryer (Energy Star) | RES_RETAIL      | All | 0.48 | 0.00            | 0.00             | 0.52 |

**2024**

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------|-----------------|-----|------|-----------------|------------------|------|
| Dryer (Energy Star) | RES_RETAIL      | All | 0.48 | 0.00            | 0.00             | 0.52 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 1** : DOE (2015). 10 CFR Part 431 March 27, 2015. Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers. Table II.7. <http://www.gpo.gov/fdsys/pkg/FR-2015-03-27/pdf/2015-07058.pdf>
- 2** : DOE (2015). 10 CFR Part 431 March 27, 2015. Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers. Table II.7. <http://www.gpo.gov/fdsys/pkg/FR-2015-03-27/pdf/2015-07058.pdf>
- 3** : DOE (2013). 10 CFR Parts 429 and 430 August 14, 2013. Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule. Table 11.1. <http://www.gpo.gov/fdsys/pkg/FR-2013-08-14/pdf/2013-18931.pdf>
- 4** : DOE (2013). 10 CFR Parts 429 and 430 August 14, 2013. Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule. Table 11.1. <http://www.gpo.gov/fdsys/pkg/FR-2013-08-14/pdf/2013-18931.pdf>
- 5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 6** : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 7** : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)
- 8** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 9** : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

## 1.2. Appliance - Dehumidifier

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-PL-DH   |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Plug Load   |

### Measure Description:

Rebate for the purchase of an Energy Star dehumidifier or early retirement of an existing dehumidifier.

### BCR Measure IDs:

| Measure Name           | Core Initiative                 | BCR Measure ID |
|------------------------|---------------------------------|----------------|
| Dehumidifier           | Residential Retail (RES_RETAIL) | EA2c075        |
| Dehumidifier Recycling | Residential Retail (RES_RETAIL) | EA2c076        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta \text{kWh New} = \text{Dehumidification Load} * ((1/\text{EffBase}) - (1/\text{EffEE}))$$

$$\Delta \text{kWh Recycling} = \text{Dehumidification Load} * ((1/\text{EffRetire}) - (1/\text{EffBase}))$$

Where:

Dehumidification Load = Typical annual moisture removal, in Liters/year. Average annual dehumidification load is 1,520 Liters/year.<sup>1</sup>

EffRETIRE = Average efficiency of model being recycled, in Liters/kWh (1.6 Liters/kWh)

EffBASE = Average efficiency of model meeting the federal standard, in Liters/kWh (2.8 Liters/kWh)

EffEE = Efficiency of ENERGY STAR® model, in Liters/kWh (3.3 Liters/kWh)

Dehumidifier Recycling savings is from an evaluation study.<sup>2</sup>

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

| Measure Name           | $\Delta \text{kWh}$ | $\Delta \text{kW}$ |
|------------------------|---------------------|--------------------|
| Dehumidifier           | 82.3                | 0.02               |
| Dehumidifier Recycling | 1,020               | 0.24               |

**Baseline Efficiency:**

The baseline efficiency for rebates on new equipment is a unit meeting the current federal standard (2.8 Liters/kWh).<sup>4</sup> The baseline efficiency for recycling is a unit that is approximately 8 years old, meeting the standard that was in place at the time (1.6 Liters/kWh).<sup>5</sup>

**High Efficiency:**

The high efficiency case for rebates on new equipment is an ENERGY STAR® unit (3.3 Liters/kWh).<sup>6</sup> The high efficiency case for recycling is a new unit that meets the current federal standard (2.8 Liters/kWh).

**Measure Life:**

The measure life is 17 years for the dehumidifier and 4 years for dehumidifier recycling.<sup>7</sup>

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Dehumidifier           | RES_RETAIL      | All | 17  | n/a | n/a | 17  |
| Dehumidifier Recycling | RES_RETAIL      | All | 4   | n/a | n/a | 4   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Dehumidifier           | RES_RETAIL      | All | 0.99 | 1.00            | n/a              | 1.00             | 1.00             | 0.82             | 0.17             |
| Dehumidifier Recycling | RES_RETAIL      | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.82             | 0.17             |

**In-Service Rates:**

In-service rate for units incentivized through rebates is based on evaluation results.<sup>8</sup> For recycling, in service rates are 100% because recycled units are collected.

**Realization Rates:**

Realization rates are set to 100% as unit savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>9</sup>

## Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.<sup>10 11</sup>

### 2022

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Dehumidifier | RES_RETAIL      | All | 0.51 | 0.00            | 0.00             | 0.49 |

### 2023

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Dehumidifier | RES_RETAIL      | All | 0.53 | 0.00            | 0.00             | 0.47 |

### 2024

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Dehumidifier | RES_RETAIL      | All | 0.55 | 0.00            | 0.00             | 0.45 |

### 2022-2024

| Measure Name           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------|-----------------|-----|------|-----------------|------------------|------|
| Dehumidifier Recycling | RES_RETAIL      | All | 0.59 | 0.00            | 0.00             | 0.41 |

## Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

## Endnotes:

1 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)

2 : Guidehouse (2021). Appliance Recycling Impact Study

[2021 Guidehouse Appliance Recycling 2019 Impact Report](#)

3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

4 : 2020 Current Federal Standard: <https://www.ecfr.gov/cgi-bin/text-idx?rgn=div8&node=10:3.0.1.4.18.3.9.2>

5 : 2012 Federal Standard

6 : [ENERGY STAR Dehumidifiers Version 5](#)

7 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)

8 : NMR Group Inc. (2021). Residential Products In Service Rates Memo. [2021 NMR Products ISR](#)

9 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

10 : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

11 : NMR Group, Inc. (2021). Appliance Recycling NTG Report.

[2021 NMR Appliance Recycling NTG Report](#)



### 1.3. Appliance - Early Retirement Clothes Washer

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-A-ERCW  |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Appliances  |

#### Measure Description:

The replacement and recycling of a working top-loading clothes washer with an agitator with an Energy Star rated washing machine.

#### BCR Measure IDs:

| Measure Name                                             | Core Initiative                 | BCR Measure ID |
|----------------------------------------------------------|---------------------------------|----------------|
| Early Retirement CW Elec DHW & Elec Dryer - Retire       | Residential Retail (RES_RETAIL) | EA2c301        |
| Early Retirement CW Elec DHW & Elec Dryer - EE           | Residential Retail (RES_RETAIL) | EA2c302        |
| Early Retirement CW Gas DHW & Elec Dryer - Retire        | Residential Retail (RES_RETAIL) | EA2c303        |
| Early Retirement CW Gas DHW & Elec Dryer - EE            | Residential Retail (RES_RETAIL) | EA2c304        |
| Early Retirement CW Elec DHW & Gas Dryer - Retire        | Residential Retail (RES_RETAIL) | EA2c305        |
| Early Retirement CW Elec DHW & Gas Dryer - EE            | Residential Retail (RES_RETAIL) | EA2c306        |
| Early Retirement CW Oil DHW & Elec Dryer - Retire        | Residential Retail (RES_RETAIL) | EA2c307        |
| Early Retirement CW Oil DHW & Elec Dryer - EE            | Residential Retail (RES_RETAIL) | EA2c308        |
| Early Retirement CW Gas DHW & Gas Dryer - Retire         | Residential Retail (RES_RETAIL) | EA2c309        |
| Early Retirement CW Gas DHW & Gas Dryer - EE             | Residential Retail (RES_RETAIL) | EA2c310        |
| Early Retirement CW Propane DHW & Elec Dryer - Retire    | Residential Retail (RES_RETAIL) | EA2c311        |
| Early Retirement CW Propane DHW & Elec Dryer - EE        | Residential Retail (RES_RETAIL) | EA2c312        |
| Early Retirement CW (EE) Gas DHW & Elec Dryer            | Residential Retail (RES_RETAIL) | GA2c050        |
| Early Retirement CW (Retire) Gas DHW & Elec Dryer        | Residential Retail (RES_RETAIL) | GA2c051        |
| Early Retirement CW (EE) Gas DHW & Elec Dryer (Muni)     | Residential Retail (RES_RETAIL) | GA2c052        |
| Early Retirement CW (Retire) Gas DHW & Elec Dryer (Muni) | Residential Retail (RES_RETAIL) | GA2c053        |
| Early Retirement CW (EE) Elec DHW & Gas Dryer            | Residential Retail (RES_RETAIL) | GA2c054        |

|                                                          |                                 |         |
|----------------------------------------------------------|---------------------------------|---------|
| Early Retirement CW (Retire) Elec DHW & Gas Dryer        | Residential Retail (RES_RETAIL) | GA2c055 |
| Early Retirement CW (EE) Elec DHW & Gas Dryer (Muni)     | Residential Retail (RES_RETAIL) | GA2c056 |
| Early Retirement CW (Retire) Elec DHW & Gas Dryer (Muni) | Residential Retail (RES_RETAIL) | GA2c057 |
| Early Retirement CW (EE) Gas DHW & Gas Dryer             | Residential Retail (RES_RETAIL) | GA2c058 |
| Early Retirement CW (Retire) Gas DHW & Gas Dryer         | Residential Retail (RES_RETAIL) | GA2c059 |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = [(Capacity \times 1/IMEF_{base} \times N_{cycles}) \times (\%CW_{kwh_{base}} + \%DHW_{kwh_{base}} + \%Dryer_{kwh_{base}})]$$

$$- [(Capacity \times 1/IMEF_{eff} \times N_{cycles}) \times (\%CW_{kwh_{eff}} + \%DHW_{kwh_{eff}} + \%Dryer_{kwh_{eff}})]$$

$$\Delta MMBTUs = [(Capacity \times 1/MEF_{base} \times N_{cycles}) \times (\%DHW_{ff_{base}} \times r_{eff}) + \%Dryer_{ff_{base}}] - [(Capacity \times 1/MEF_{eff} \times N_{cycles}) \times (\%DHW_{ff_{eff}} \times r_{eff}) + \%Dryer_{gaseff}] \times MMBTU_{convert}$$

Where:

Capacity = washer volume in ft<sup>3</sup>.

IMEF = Integrated Modified Energy Factor and is measured in ft<sup>3</sup>/kWh/cycle

Ncycles = 283 loads per year<sup>1</sup>

%CW<sub>kwh</sub> = % of total kWh energy consumption for clothes washer operation (different for baseline and efficient unit). See table below

%DHW<sub>kwh</sub> = % of total kWh energy consumption used for water heating (different for baseline and efficient unit). See table below. If water is heated by gas or propane this is 0%

%DHW<sub>ff</sub> = % of total kWh energy consumption for dryer operation (different for baseline and efficient unit). See table below. If the dryer is gas this is 0%

%Dryer<sub>kwh</sub> = % of total fossil fuel energy consumption used for water heating (different for baseline and efficient unit). See table below. If water is heated by electric this is 0%.

%Dryer<sub>ff</sub> = % of total fossil fuel energy consumption for dryer operation (different for baseline and efficient unit). See table below. If the dryer is electric this is 0%.

r<sub>eff</sub> = recovery energy factor used to account for the difference in recovery efficiencies of electric and gas/oil/propane hot water heaters. Electric water heaters are 100% efficient while other water heaters are 75% efficient. The ratio is 1.33 (100%/75%)

MMBTU<sub>convert</sub> = Conversion factor from kWh to MMBTU is 0.003412

### Efficiency Ratings and Percentage of Total Energy Consumption<sup>2</sup>

|                                     | % Energy used for: |               |        | IMEF                       | IWF                           | Volume          |
|-------------------------------------|--------------------|---------------|--------|----------------------------|-------------------------------|-----------------|
|                                     | Washer operation   | Water heating | Drying | ft <sup>3</sup> /kWh/cycle | gallons/cycle/ft <sup>3</sup> | ft <sup>3</sup> |
| Existing-Top Loading CW             | 8%                 | 34%           | 59%    | 0.84                       | 9.92                          | 3.1             |
| New-Federal Standard Top Loading CW | 3%                 | 40%           | 56%    | 1.57                       | 6.50                          | 3.9             |
| New-Energy Star Top Loading CW      | 4%                 | 31%           | 65%    | 2.06                       | 4.30                          | 4.3             |

### **Savings from Early Retirement of Clothes Washers**

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

| Measure Name                                          | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|-------------------------------------------------------|--------------|-------------|----------------|
| Early Retirement CW (Retire) Elec DHW & Elec Dryer    | 342          | 0.1         | 0              |
| Early Retirement CW (EE) Elec DHW & Elec Dryer        | 112          | 0.03        | 0              |
| Early Retirement CW (Retire) Gas DHW & Elec Dryer     | 272          | 0.08        | 0.32           |
| Early Retirement CW (EE) Gas DHW & Elec Dryer         | 12           | 0           | 0.46           |
| Early Retirement CW (Retire) Elec DHW & Gas Dryer     | 125          | 0.04        | 0.74           |
| Early Retirement CW (EE) Elec DHW & Gas Dryer         | 101          | 0.03        | 0.04           |
| Early Retirement CW (Retire) Gas DHW & Gas Dryer      | 56           | 0.02        | 0.32 / 0.74    |
| Early Retirement CW (EE) Gas DHW & Gas Dryer          | 0.8          | 0           | 0.46 / 0.04    |
| Early Retirement CW (Retire) Oil DHW & Elec Dryer     | 272          | 0.08        | 0.32           |
| Early Retirement CW (EE) Oil DHW & Elec Dryer         | 12           | 0           | 0.46           |
| Early Retirement CW (Retire) Propane DHW & Elec Dryer | 272          | 0.08        | 0.32           |
| Early Retirement CW (EE) Propane DHW & Elec Dryer     | 12           | 0           | 0.46           |

### **Baseline Efficiency:**

It is assumed that the existing top loading clothes washer met the 2007 federal standard which was an MEF > 1.262 and WF < 9.53. This is equivalent to an IMEF of 0.84 and IWF of 9.92. A new standard efficiency clothes washer meets the federal standard for top loading washers effective 1/1/18 which requires an IMEF > 1.57 and an IWF < 6.5.

MEF is Modified Energy Factor and is measured in  $ft^3/kWh/cycle$

WF is Water Factor and is measured in gallons/cycle/ft

IMEF is Integrated Modified Energy Factor and is measured in  $ft^3/kWh/cycle$

IWF is Integrated Water Factor and is measured in gallons/cycle/ft<sup>3</sup>

### **High Efficiency:**

The new high efficiency washer is an Energy Star (Version 8.0) rated washer top loading washer with a minimum IMEF > 2.06 and IWF < 4.3.<sup>4</sup>

### **Measure Life:**

The effective useful life of the new clothes washer is assumed to be 12 years.<sup>5</sup> The remaining useful life of the existing clothes washer is assumed to be 1/3 of the effective useful life which is 4 years.

| Measure Name                 | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------|-----------------|-----|-----|-----|-----|-----|
| Early Retirement CW (Retire) | RES_CD          | All | 4   | n/a | n/a | 4   |
| Early Retirement CW (EE)     | RES_CD          | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

Water savings are calculated using the following algorithm:

$$\Delta\text{Water (gallons)} = (\text{Capacity} * (\text{IWFbase} - \text{IWFeff})) * \text{Ncycles}$$

Water savings for the Retire portion is 1,568 gallons and 1,903 gallons for the EE portion. Total water savings are 3,471 gallons.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                 | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Early Retirement CW (Retire) | RES_CD          | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.42             | 0.56             |
| Early Retirement CW (EE)     | RES_CD          | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.42             | 0.56             |

**In-Service Rates:**

In-service rates are set to 100% based on the assumption that all purchased units are installed.

**Realization Rates:**

Realization rates are based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values have not been studied. The default NTG is 1.00.

| Measure Name                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Early Retirement CW (Retire) | RES_CD          | All | 0.00 | 0.00            | 0.00             | 1.00 |

|                          |        |     |      |      |      |      |
|--------------------------|--------|-----|------|------|------|------|
| Early Retirement CW (EE) | RES_CD | All | 0.00 | 0.00 | 0.00 | 1.00 |
|--------------------------|--------|-----|------|------|------|------|

### Non-Energy Impacts:

There are no NEIs associated with this measure.

### Endnotes:

**1** : DOE (2013). 10 CFR Parts 429 and 430 Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule. [DOE 2013 Test Procedures for Residential Clothes Dryers](#)

**2** : DOE (2012). Residential Clothes Washers Direct Final Rule Technical Support Document; Chapter 7. [DOE 2012 Technical Support Document Clothes Washers](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**4** : New Energy Star standard for top loading washers as of 2/15/2018

**5** : Environmental Protection Agency (2018). Savings Calculator for ENERGY STAR Qualified Appliances.

[https://www.energystar.gov/sites/default/files/asset/document/appliance\\_calculator.xlsx](https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx)

[Energy Star 2018 Consumer Appliance Calc](#)

**6** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.4. Appliance - Refrigerator/Freezer Recycling

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-A-RFR   |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Appliances  |

### Measure Description:

The retirement of old, inefficient refrigerators and freezers.

### BCR Measure IDs:

| Measure Name                      | Core Initiative                 | BCR Measure ID |
|-----------------------------------|---------------------------------|----------------|
| Freezer Recycling                 | Residential Retail (RES_RETAIL) | EA2c052        |
| Refrigerator Recycling (Combined) | Residential Retail (RES_RETAIL) | EA2c066        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed and are obtained from the referenced study.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name           | $\Delta kWh$ | $\Delta kW$ |
|------------------------|--------------|-------------|
| Freezer Recycling      | 753          | 0.13        |
| Refrigerator Recycling | 1005         | 0.17        |

### Baseline Efficiency:

The baseline efficiency case is an old, inefficient working refrigerator or freezer.

### High Efficiency:

The high efficiency case assumes no replacement of the recycled unit.

### Measure Life:

The measure life is 4 years.

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Freezer Recycling      | RES_RETAIL      | All | 4   | n/a | n/a | 4   |
| Refrigerator Recycling | RES_RETAIL      | All | 4   | n/a | n/a | 4   |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Freezer Recycling      | RES_RETAIL      | All | 1.00 | 0.83            | 0.83             | 0.83             | 0.83             | 0.85             | 0.65             |
| Refrigerator Recycling | RES_RETAIL      | All | 1.00 | 0.88            | 0.88             | 0.88             | 0.88             | 0.85             | 0.65             |

### In-Service Rates:

All installations have 100% in service rate.

### Realization Rates:

Realization rates represent the Part Use Factor, and account for units not being plugged in for the entire year.<sup>3</sup>

### Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

Net-to-gross factors are based on study results.<sup>5</sup>

| Measure Name           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------|-----------------|-----|------|-----------------|------------------|------|
| Freezer Recycling      | RES_RETAIL      | All | 0.50 | 0.00            | 0.00             | 0.50 |
| Refrigerator Recycling | RES_RETAIL      | All | 0.54 | 0.00            | 0.00             | 0.46 |

### Non-Energy Impacts:

There are no non-energy impacts identified with this measure.

### Endnotes:

1 : Guidehouse (2021). Appliance Recycling Impact Study.

[2021 Guidehouse Appliance Recycling 2019 Impact Report](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**3** : Guidehouse (2021). Appliance Recycling Impact Study

[2021 Guidehouse Appliance Recycling 2019 Impact Report](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**5** : NMR Group, Inc. (2021). Appliance Recycling NTG Report. [2021 NMR Appliance Recycling NTG Report](#)



## 1.5. Appliance - Room Air Cleaner

|                     |              |
|---------------------|--------------|
| <b>Measure Code</b> | RES-PL-RAC   |
| <b>Market</b>       | Residential  |
| <b>Program Type</b> | Time of Sale |
| <b>Category</b>     | Plug Load    |

### Measure Description:

Rebates provided for the purchase of an ENERGY STAR® qualified room air cleaner. ENERGY STAR® air cleaners are 40% more energy-efficient than standard models.

### BCR Measure IDs:

| Measure Name     | Core Initiative                 | BCR Measure ID |
|------------------|---------------------------------|----------------|
| Room Air Cleaner | Residential Retail (RES_RETAIL) | EA2c072        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on averaged inputs.<sup>1</sup> The weight is based on 2019 - Aug 2020 National Grid rebated units.

| CADR Range | CADR Value in Calculator | Baseline Consumption (kWh) | High Efficiency Consumption (kWh) | Energy Savings (kWh) | Weight |
|------------|--------------------------|----------------------------|-----------------------------------|----------------------|--------|
| 51-100     | 75                       | 441                        | 148                               | 293                  | 11%    |
| 101-150    | 125                      | 733                        | 245                               | 488                  | 33%    |
| 151-200    | 175                      | 1025                       | 342                               | 683                  | 15%    |
| 201-250    | 225                      | 1317                       | 440                               | 877                  | 22%    |
| Over 250   | 300                      | 1755                       | 586                               | 1169                 | 19%    |

kW savings is based on a 24 hour operation.

| Measure Name     | kWh | kW   |
|------------------|-----|------|
| Room Air Cleaner | 713 | 0.08 |

### Baseline Efficiency:

The baseline efficiency case is a unit with 1.0 CADR/Watt<sub>dust</sub>.<sup>2</sup>

**High Efficiency:**

The current EnergyStar specification requires a minimum of 2.0 CADR/Watt<sub>dust</sub>. However, the ENERGY STAR average CADR/Watt (Dust) of models available in their US market database (approximately 170 models) is approximately 3.5 CADR/Watt<sub>dust</sub>. Therefore it is assumed that the high efficiency unit has a 3.0 CADR/Watt<sub>dust</sub>

**Measure Life:**

The measure life is 9 years.<sup>2</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Room Air Cleaner | RES_RETAIL      | All | 9   | n/a | n/a | 9   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name     | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Room Air Cleaner | RES_RETAIL      | All | 0.97 | 1.00            | n/a              | 1.00             | 1.00             | 1.00             | 1.00             |

**In-Service Rates:**

In-service rates is based on evaluation results.<sup>3</sup>

**Realization Rates:**

Realization rates are set to 100% since unit savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are calculated assuming that the unit runs continuously, 8760 hours/year.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results and are weighted based on 2020 sales (53% in-store and 47% online).<sup>4</sup>

**2022**

| Measure Name     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Cleaner | RES_RETAIL      | All | 0.34 | 0.00            | 0.00             | 0.66 |

**2023**

| Measure Name     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Cleaner | RES_RETAIL      | All | 0.36 | 0.00            | 0.00             | 0.64 |

**2024**

| Measure Name     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Cleaner | RES_RETAIL      | All | 0.37 | 0.00            | 0.00             | 0.63 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 
- 1 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
  - 2 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances. [Energy Star 2018 Consumer Appliance Calc](#)
  - 3 : NMR Group Inc. (2021). Residential Products In Service Rates Memo. [2021 NMR Products ISR](#)
  - 4 : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

## 1.6. Appliances - Ultra Low GWP Refrigerator

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | RES-CM-REF       |
| <b>Market</b>       | Residential      |
| <b>Program Type</b> | Lost Opportunity |
| <b>Category</b>     | Appliances       |

### Measure Description:

Rebates for purchase of Energy Star Most Efficiency qualified refrigerators using a natural refrigerant.

### BCR Measure IDs:

| Measure                    | Core Initiative                 | BCR Measure ID |
|----------------------------|---------------------------------|----------------|
| Ultra Low GWP Refrigerator | Residential Retail (RES_RETAIL) | EA2c342        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = kWh_{base} - kWh_{HE}$$

Where:

$kWh_{base}$  = Average usage of a new refrigerator meeting federal standards, by model type

$kWh_{HE}$  = Average usage of a new natural refrigerant refrigerator meeting ENERGY STAR® Most Efficient Standards, by model type

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>1</sup>

| Measure                    | $\Delta kWh^2$ | $\Delta kW$ |
|----------------------------|----------------|-------------|
| Ultra Low GWP Refrigerator | 101            | 0.02        |

### Baseline Efficiency:

The baseline efficiency case is a residential refrigerator that meets the federal minimum standard for energy efficiency and uses a conventional refrigerator.

**High Efficiency:**

The high efficiency case is an ENERGY STAR most efficient qualified residential refrigerator that uses a natural refrigerant.

**Measure Life:**

The measure life is 12 years.<sup>3</sup>

| Measure Name               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------|-----------------|-----|-----|-----|-----|-----|
| Ultra Low GWP Refrigerator | RES_RETAIL      | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are GHG savings related to refrigerant disposal associated with this measure.<sup>4</sup>

| Measure Name               | Annual GHG savings (MT CO2e/unit) |
|----------------------------|-----------------------------------|
| Ultra Low GWP Refrigerator | 0.001                             |

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Ultra Low GWP Refrigerator | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.85             | 0.65             |

**In-Service Rates:**

The in-service rate is assumed to be 100%.

**Realization Rates:**

Realization rates are based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Assumed 10% free-ridership.

| Measure Name               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------|-----------------|-----|------|-----------------|------------------|------|
| Ultra Low GWP Refrigerator | RES_RETAIL      | All | 0.10 | 0.00            | 0.00             | 0.90 |

**Non-Energy Impacts:**

There are no non-energy impacts for this measure.

**Endnotes:**

- 1: Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 2: Apex Analytics (2021). Refrigerator Savings Modeling [2021 APEX Analytics Refrigerators Savings Modeling](#)
- 3: Energy Star (2018). Consumer Appliance Calculator [Energy Star 2018 Consumer Appliance Calc](#)
- 4: [2021 NationalGrid Ultra Low GWP Resi Refrig GHG](#)
- 5: Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.7. Behavior - Home Energy Report

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-O-HER   |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Behavior    |
| <b>Category</b>     | Other       |

### Measure Description:

The Behavior/Feedback programs send energy use reports to participating electric and natural gas customers in order to change customers' energy-use behavior.

### BCR Measure IDs:

| Measure Name        | Core Initiative                  | BCR Measure ID |
|---------------------|----------------------------------|----------------|
| Home Energy Reports | Residential Behavior (RES_BEHVR) | EA2d001        |
| Home Energy Reports | Residential Behavior (RES_BEHVR) | GA2d001        |

### Algorithms for Calculating Primary Energy Impact:

National Grid, Unitil, CLC and Berkshire unit savings are custom and based on calculations from vendor results.

$$\Delta \text{kWh} = (\text{kWh}_{\text{BASE}}) (\% \text{SAVE})$$

$$\Delta \text{MMBtu} = (\text{MMBtu}_{\text{BASE}}) (\% \text{SAVE})$$

Where:

Unit = One participant household.

kWh/MMBTU<sub>BASE</sub> = Baseline energy consumption kWh/MMBTU.

%SAVE = Energy savings percent per program participant.

The Eversource savings for the Delivered Energy Insights will use savings of 0.428 mmbtu per gas customer and 45.55 kWh per electric customer based on study results.<sup>1</sup>

### Baseline Efficiency:

The baseline efficiency case is a customer who does not receive a Home Energy Report.

### High Efficiency:

The high efficiency case is a customer who receives a Home Energy Report.

### Measure Life:

The measure life is 1 year.

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                    | Core Initiative | PA            | Fuel Type | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------|-----------------|---------------|-----------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Home Energy Reports Persistence | RES_BEHVR       | Eversource    | Elec      | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.19             | 0.35             |
| Home Energy Reports             | RES_BEHVR       | National Grid | Elec      | 1.00 | 0.95            | n/a              | 0.95             | 0.95             | 0.19             | 0.35             |
| Home Energy Reports             | RES_BEHVR       | CLC           | Elec      | 1.00 | 1.04            | n/a              | 1.00             | 1.00             | 0.19             | 0.35             |
| Home Energy Reports             | RES_BEHVR       | Unitil        | Elec      | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.19             | 0.35             |
| Home Energy Reports             | RES_BEHVR       | National Grid | Gas       | 1.00 | n/a             | 0.98             | n/a              | n/a              | n/a              | n/a              |
| Home Energy Reports Persistence | RES_BEHVR       | Eversource    | Gas       | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Home Energy Reports             | RES_BEHVR       | Berkshire     | Gas       | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Home Energy Reports             | RES_BEHVR       | Unitil        | Gas       | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

In-services rates are 100% since the program tracks all participating customers.

**Realization Rates:**

Eversource HER program persistence savings assume a 100% realization rate based on a 2021 evaluation.<sup>1</sup> All other PA realization rates are based on 2015 evaluation results.<sup>2</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

The PAs assume 100% net-to-gross.



**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

---

**1** : Guidehouse (2021) Re: 2020 Persistence Savings from the Home Energy Reports Program

**2** : Navigant Consulting and Illume Advising (2015). Behavior Program Evaluation Opower Results. Navigant\_Illume\_2014\_Behavior\_Program\_Impact\_Evaluation

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.8. Building Shell - Air Sealing

|                     |                |
|---------------------|----------------|
| <b>Measure Code</b> | RES-BS-AS      |
| <b>Market</b>       | Residential    |
| <b>Program Type</b> | Retrofit       |
| <b>Category</b>     | Building Shell |

### Measure Description:

Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.

### BCR Measure IDs:

| Measure Name                                                          | Core Initiative                           | BCR Measure ID |
|-----------------------------------------------------------------------|-------------------------------------------|----------------|
| Air Sealing, Electric (Single Family)                                 | Residential Coordinated Delivery (RES_CD) | EA2a028        |
| Air Sealing, Gas (Single Family)                                      | Residential Coordinated Delivery (RES_CD) | EA2a029        |
| Air Sealing, Oil (Single Family)                                      | Residential Coordinated Delivery (RES_CD) | EA2a030        |
| Air Sealing, Other (Single Family)                                    | Residential Coordinated Delivery (RES_CD) | EA2a031        |
| Moderate Income Qualified - Air Sealing, Electric (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a301        |
| Moderate Income Qualified - Air Sealing, Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a302        |
| Moderate Income Qualified - Air Sealing, Oil (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a303        |
| Moderate Income Qualified - Air Sealing, Other (Single Family)        | Residential Coordinated Delivery (RES_CD) | EA2a304        |
| Air Sealing, Electric (Attached Low Rise)                             | Residential Coordinated Delivery (RES_CD) | EA2a105        |
| Air Sealing, Gas (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a293        |
| Air Sealing, Oil (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a106        |
| Air Sealing, Other (Attached Low Rise)                                | Residential Coordinated Delivery (RES_CD) | EA2a107        |
| Moderate Income Qualified - Air Sealing, Electric (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a309        |
| Moderate Income Qualified - Air Sealing, Gas (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a310        |

|                                                                    |                                           |         |
|--------------------------------------------------------------------|-------------------------------------------|---------|
| Moderate Income Qualified - Air Sealing, Oil (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a311 |
| Moderate Income Qualified - Air Sealing, Other (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a312 |
| Air Sealing, Electric (High Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a193 |
| Air Sealing, Oil (High Rise)                                       | Residential Coordinated Delivery (RES_CD) | EA2a194 |
| Air Sealing, Other (High Rise)                                     | Residential Coordinated Delivery (RES_CD) | EA2a195 |
| Air Sealing, Gas (Single Family)                                   | Residential Coordinated Delivery (RES_CD) | GA2a001 |
| Air Sealing, Gas (Attached Low Rise)                               | Residential Coordinated Delivery (RES_CD) | GA2a046 |
| Moderate Income Qualified - Air Sealing, Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | GA2a132 |
| Moderate Income Qualified - Air Sealing, Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | GA2a059 |
| Air Sealing, Gas (High Rise)                                       | Residential Coordinated Delivery (RES_CD) | GA2a079 |

## Algorithms for Calculating Primary Energy Impact:

### Single Family and Low Rise Attached:

The Program Administrators currently use vendor calculated energy savings for these measures in the Residential Coordinated Delivery electric program. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The proprietary building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms. Infiltration savings use site-specific seasonal N-factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 as their basis. Lighting, appliance, and water heating savings are based on standard algorithms, taking into account operating conditions and pre- and post-retrofit energy consumption. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly “adding” individual measure results.

The PAs calculate demand (kW) savings by applying a kW/kWh factor to the vendor-estimated electric energy savings. The kW/kWh factor for Air Sealing (Electric) is 0.00073.<sup>1</sup>

### High Rise:

Unit savings are calculated using the following algorithms and assumptions:

$$\text{MMBtu} = (\text{Vol} \times \Delta\text{ACH} \times 0.018 \times \text{HDD60} \times 24) / (1,000,000 * \eta_{\text{heating}})$$

$$\text{kWh} = \text{MMBtu} * 293.1$$

$$\text{kW} = \text{kWh} \times \text{kW/kWh}$$

Where:

Vol = [ft<sup>3</sup>] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)

ΔACH = [°F-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value<sup>2</sup> or Blower Door Test)

HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below.

η<sub>heating</sub> = [AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)

24 = Conversion factor: 24 hours per day

0.018 = [Btu/ft<sup>3</sup>- °F] Air heat capacity: The specific heat of air (0.24 Btu/°F.lb) times the density of air (0.075 lb/ft<sup>3</sup>)

1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu

293.1 = Conversion factor: 293.1 kWh / MMBtu

kW/kWh = Average kW reduction per kWh reduction: 0.00073 kW/kWh<sup>3</sup>

Hours:

Heating hours are characterized by the heating degree days for the facility.<sup>4</sup> The heating degree days are looked up based on the nearest weather station to the customer, as selected by the program vendor.

| TMY3 City               | HDD   | CDH   |
|-------------------------|-------|-------|
| Barnstable Muni Boa     | 4,379 | 1,349 |
| Beverly Muni            | 5,329 | 3,432 |
| Boston Logan Int'l Arpt | 4,550 | 4,329 |
| Chicopee Falls Westo    | 5,016 | 4,116 |
| Lawrence Muni           | 4,640 | 3,978 |
| Martha's Vineyard       | 4,312 | 1,345 |
| Nantucket Memorial AP   | 3,988 | 362   |
| New Bedford Rgnl        | 4,434 | 4,232 |
| North Adams             | 5,234 | 2,524 |
| Norwood Memorial        | 4,872 | 4,763 |
| Otis ANGBb              | 4,718 | 2,588 |
| Plymouth Municipal      | 4,559 | 2,138 |
| Provincetown (AWOS)     | 4,368 | 2,195 |

|                          |       |       |
|--------------------------|-------|-------|
| Westfield Barnes Muni AP | 5,301 | 3,784 |
| Worcester Regional Arpt  | 5,816 | 1,753 |

### Baseline Efficiency:

The baseline efficiency case is the existing building before the air sealing measure is implemented. For High Rise, the baseline building is characterized by the existing air changes per hour (ACHPRE) for multi-family facilities, which is measured prior to the implementation of the air sealing measure. This will typically be a default value of a baseline/pre-retrofit ACH =0.5.

### High Efficiency:

The high efficiency case is the existing building after the air sealing measure is implemented. For High Rise, the high efficiency building is characterized by the new air changes per hour (ACHPOST) for multi-family facilities, which is measured after the air sealing measure is implemented. This will typically be a default value of a post-retrofit ACH =0.4.

### Measure Life:

The measure life is 15 years.<sup>5</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Air Sealing  | RES_CD          | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

Moderate Income Qualified use the same impact factors.

| Measure Name                              | Core Initiative | PA    | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------|-----------------|-------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Air Sealing, Electric (Single Family)     | RES_CD          | NGRID | 1.00 | 0.56            | n/a              | 0.56             | 0.56             | 0.00             | 0.43             |
| Air Sealing, Gas (Single Family)          | RES_CD          | NGRID | 1.00 | n/a             | 0.75             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Oil (Single Family)          | RES_CD          | NGRID | 1.00 | n/a             | 0.77             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Other (Single Family)        | RES_CD          | NGRID | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Electric (Attached Low Rise) | RES_CD          | NGRID | 1.00 | 0.56            | n/a              | 0.56             | 0.56             | 0.00             | 0.43             |

|                                           |        |            |      |      |      |      |      |      |      |
|-------------------------------------------|--------|------------|------|------|------|------|------|------|------|
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | NGRID      | 1.00 | n/a  | 0.75 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Attached Low Rise)      | RES_CD | NGRID      | 1.00 | n/a  | 0.77 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (Attached Low Rise)    | RES_CD | NGRID      | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (Single Family)     | RES_CD | Eversource | 1.00 | 0.56 | n/a  | 0.56 | 0.56 | 0.00 | 0.43 |
| Air Sealing, Gas (Single Family)          | RES_CD | Eversource | 1.00 | n/a  | 0.75 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Single Family)          | RES_CD | Eversource | 1.00 | n/a  | 0.77 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (Single Family)        | RES_CD | Eversource | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (Attached Low Rise) | RES_CD | Eversource | 1.00 | 0.56 | n/a  | 0.56 | 0.56 | 0.00 | 0.43 |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | Eversource | 1.00 | n/a  | 0.75 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Attached Low Rise)      | RES_CD | Eversource | 1.00 | n/a  | 0.77 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (Attached Low Rise)    | RES_CD | Eversource | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (Single Family)     | RES_CD | Unitil     | 1.00 | 0.54 | n/a  | 0.54 | 0.54 | 0.00 | 0.43 |
| Air Sealing, Gas (Single Family)          | RES_CD | Unitil     | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Single Family)          | RES_CD | Unitil     | 1.00 | n/a  | 0.79 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (Single Family)        | RES_CD | Unitil     | 1.00 | n/a  | 0.89 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (Attached Low Rise) | RES_CD | Unitil     | 1.00 | 0.54 | n/a  | 0.54 | 0.54 | 0.00 | 0.43 |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | Unitil     | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Attached Low Rise)      | RES_CD | Unitil     | 1.00 | n/a  | 0.79 | n/a  | n/a  | n/a  | n/a  |

|                                           |        |           |      |      |      |      |      |      |      |
|-------------------------------------------|--------|-----------|------|------|------|------|------|------|------|
| Air Sealing, Other (Attached Low Rise)    | RES_CD | Unitil    | 1.00 | n/a  | 0.89 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (Single Family)     | RES_CD | CLC       | 1.00 | 0.54 | n/a  | 0.54 | 0.54 | 0.00 | 0.43 |
| Air Sealing, Gas (Single Family)          | RES_CD | CLC       | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Single Family)          | RES_CD | CLC       | 1.00 | n/a  | 0.79 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (Single Family)        | RES_CD | CLC       | 1.00 | n/a  | 0.89 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (Attached Low Rise) | RES_CD | CLC       | 1.00 | 0.54 | n/a  | 0.54 | 0.54 | 0.00 | 0.43 |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | CLC       | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Oil (Attached Low Rise)      | RES_CD | CLC       | 1.00 | n/a  | 0.79 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (Attached Low Rise)    | RES_CD | CLC       | 1.00 | n/a  | 0.89 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Gas (Single Family)          | RES_CD | Berkshire | 1.00 | n/a  | 0.83 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | Berkshire | 1.00 | n/a  | 0.83 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Gas (Single Family)          | RES_CD | Columbia  | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | Columbia  | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Gas (Single Family)          | RES_CD | Liberty   | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD | Liberty   | 1.00 | n/a  | 0.68 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Electric (High Rise)         | RES_CD | All       | 1.00 | 0.86 | n/a  | 0.86 | 0.86 | 0.00 | 0.43 |
| Air Sealing, Oil (High Rise)              | RES_CD | All       | 1.00 | 1.00 | 0.86 | n/a  | n/a  | n/a  | n/a  |
| Air Sealing, Other (High Rise)            | RES_CD | All       | 1.00 | 1.00 | 0.86 | n/a  | n/a  | n/a  | n/a  |

|                                 |        |     |      |      |      |     |     |     |     |
|---------------------------------|--------|-----|------|------|------|-----|-----|-----|-----|
| Air Sealing,<br>Gas (High Rise) | RES_CD | All | 1.00 | 1.00 | 0.86 | n/a | n/a | n/a | n/a |
|---------------------------------|--------|-----|------|------|------|-----|-----|-----|-----|

**In-Service Rates:**

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

**Realization Rates:**

Realization rates are for Single Family and Attached Low Rise based on HES evaluation results<sup>6</sup> while High Rise is based on Multifamily evaluation results.<sup>7</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>8</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-gross factors are based on evaluation results.<sup>9</sup> Moderate Income Qualified use the same NTG values.

| Measure Name                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Air Sealing, Electric (Single Family)     | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Air Sealing, Gas (Single Family)          | RES_CD          | All | 0.19 | 0.12            | 0.04             | 0.97 |
| Air Sealing, Oil (Single Family)          | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Air Sealing, Other (Single Family)        | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Air Sealing, Electric (Attached Low Rise) | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Air Sealing, Gas (Attached Low Rise)      | RES_CD          | All | 0.19 | 0.12            | 0.04             | 0.97 |
| Air Sealing, Oil (Attached Low Rise)      | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Air Sealing, Other (Attached Low Rise)    | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Air Sealing, Electric (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Air Sealing, Oil (High Rise)              | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Air Sealing, Other (High Rise)            | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Air Sealing, Gas (High Rise)              | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name | Core Initiative | PA | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
|--------------|-----------------|----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|



|                                 |        |     |         |        |        |        |        |        |
|---------------------------------|--------|-----|---------|--------|--------|--------|--------|--------|
| Air Sealing (High Rise)         | RES_CD | All | \$19.35 | \$0.00 | \$0.00 | \$0.00 | \$0.00 | \$0.00 |
| Air Sealing (Single Family)     | RES_CD | All | \$19.28 | \$0.00 | \$0.00 | \$0.00 | \$0.00 | \$0.00 |
| Air Sealing (Low Rise Attached) | RES_CD | All | \$19.28 | \$0.00 | \$0.00 | \$0.00 | \$0.00 | \$0.00 |

**Endnotes:**

**1** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**2** : The Cadmus Group (2012). MARR Multifamily Impacts Analysis Report.

[CADMUS 2012 Multifamily Impacts Analysis Report](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**4** : The Cadmus Group, Inc. (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)

**5** : GDS\_2007\_Measure\_Life\_Report\_Residential\_and\_CI\_Lighting\_and\_HVAC\_Measures

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**6** : Navigant Consulting (2018). HES Impact Evaluation [2018 Navigant HES Impact Evaluation](#)

**7** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation

[2018 Navigant Multifamily Program Impact Evaluation](#)

**8** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**9** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Workbook [2021 Guidehouse MA Res NTG Final Results Workbook](#)

## 1.9. Building Shell - Insulation

|                     |                |
|---------------------|----------------|
| <b>Measure Code</b> | RES-BS-I       |
| <b>Market</b>       | Residential    |
| <b>Program Type</b> | Retrofit       |
| <b>Category</b>     | Building Shell |

### Measure Description:

Shell insulation installed through the Residential Coordinated Delivery program.

### BCR Measure IDs:

| Measure Name                                                         | Core Initiative                           | BCR Measure ID |
|----------------------------------------------------------------------|-------------------------------------------|----------------|
| Insulation, Electric (Single Family)                                 | Residential Coordinated Delivery (RES_CD) | EA2a032        |
| Insulation, Gas (Single Family)                                      | Residential Coordinated Delivery (RES_CD) | EA2a033        |
| Insulation, Oil (Single Family)                                      | Residential Coordinated Delivery (RES_CD) | EA2a034        |
| Insulation, Other (Single Family)                                    | Residential Coordinated Delivery (RES_CD) | EA2a035        |
| Moderate Income Qualified - Insulation, Electric (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a305        |
| Moderate Income Qualified - Insulation, Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a306        |
| Moderate Income Qualified - Insulation, Oil (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a307        |
| Moderate Income Qualified - Insulation, Other (Single Family)        | Residential Coordinated Delivery (RES_CD) | EA2a308        |
| Insulation, Electric (Attached Low Rise)                             | Residential Coordinated Delivery (RES_CD) | EA2a108        |
| Insulation, Cooling for Electrically-Heated Unit (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a109        |
| Insulation, Gas (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a294        |
| Insulation, Oil (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a110        |
| Insulation, Other (Attached Low Rise)                                | Residential Coordinated Delivery (RES_CD) | EA2a111        |
| Moderate Income Qualified - Insulation, Electric (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a313        |

|                                                                                                  |                                           |         |
|--------------------------------------------------------------------------------------------------|-------------------------------------------|---------|
| Moderate Income Qualified - Insulation, Cooling for Electrically-Heated Unit (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a314 |
| Moderate Income Qualified - Insulation, Gas (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a315 |
| Moderate Income Qualified - Insulation, Oil (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | EA2a316 |
| Moderate Income Qualified - Insulation, Other (Attached Low Rise)                                | Residential Coordinated Delivery (RES_CD) | EA2a317 |
| Insulation, Electric (High Rise)                                                                 | Residential Coordinated Delivery (RES_CD) | EA2a196 |
| Insulation, Cooling for Electrically-Heated Unit (High Rise)                                     | Residential Coordinated Delivery (RES_CD) | EA2a197 |
| Insulation, Oil (High Rise)                                                                      | Residential Coordinated Delivery (RES_CD) | EA2a198 |
| Insulation, Other (High Rise)                                                                    | Residential Coordinated Delivery (RES_CD) | EA2a199 |
| Insulation, Gas (Single Family)                                                                  | Residential Coordinated Delivery (RES_CD) | GA2a002 |
| Moderate Income Qualified - Insulation, Gas (Single Family)                                      | Residential Coordinated Delivery (RES_CD) | GA2a133 |
| Insulation, Gas (Attached Low Rise)                                                              | Residential Coordinated Delivery (RES_CD) | GA2a047 |
| Moderate Income Qualified - Insulation, Gas (Attached Low Rise)                                  | Residential Coordinated Delivery (RES_CD) | GA2a060 |
| Insulation, Gas (High Rise)                                                                      | Residential Coordinated Delivery (RES_CD) | GA2a080 |

## Algorithms for Calculating Primary Energy Impact:

### Single Family and Attached Low Rise:

The Program Administrators currently use vendor calculated energy savings for these measures in the Residential Coordinated Delivery program. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The proprietary building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms. Infiltration savings use site-specific seasonal N-factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system

and/or distribution efficiency improvements, using ASHRAE 152 as their basis. Lighting, appliance, and water heating savings are based on standard algorithms, taking into account operating conditions and pre- and post-retrofit energy consumption. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly “adding” individual measure results. The PAs calculate demand (kW) savings by applying a kW/kWh factor to the vendor-estimated electric energy savings. The kW/kWh factors are provided in the table below.

**kW Factors for Vendor Measures<sup>1</sup> :**

| Measure                                            | kW/kWh Factor |
|----------------------------------------------------|---------------|
| Insulation (Electric)                              | 0.00073       |
| Insulation (Gas, Oil, Other FF)                    | 0.00076       |
| Insulation, Central AC in Electrically-Heated Unit | 0.00059       |

**High Rise:**

$$\text{MMBtu} = ((1/R_{\text{exist}} - 1/R_{\text{new}}) * \text{HDD} * 24 * \text{Area}) / (1000000 * \eta_{\text{heat}})$$

$$\text{kWh} = \text{MMBtu} * 293.1$$

$$\text{kW} = \text{kWh} * \text{kW/kWh}_{\text{heat}}$$

Where:

- $R_{\text{exist}}$  = Existing effective R-value (R-ExistingInsulation + R-Assembly), ft<sup>2</sup>-°F/Btuh
- $R_{\text{new}}$  = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft<sup>2</sup>-°F/Btuh
- Area = Square footage of insulated area
- $\eta_{\text{heat}}$  = Efficiency of the heating system (AFUE or COP), site specific
- 293.1 = Conversion constant (1MMBtu = 293.1 kWh)
- 24 = Conversion for hours per day
- HDD = Heating Degree Days; dependent on location, see table below
- 1,000,000 = Conversion from Btu to MMBtu
- kW/kWh<sub>heat</sub> = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

*If Facility has central cooling then also calculate air conditioning savings:*

$$\text{kWh}_{\text{cool}} = ((1/R_{\text{exist}} - 1/R_{\text{new}}) * \text{CDH} * \text{DUA} * \text{Area}) / (1000 \text{ Btu/kBtu} * \eta_{\text{cool}})$$

$$\text{kW} = \text{kWh} * \text{kW/kWh}_{\text{cool}}$$

Where:

- $R_{\text{exist}}$  = Existing effective R-value (R-ExistingInsulation + R-Assembly), ft<sup>2</sup>-°F/Btuh
- $R_{\text{new}}$  = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft<sup>2</sup>-°F/Btuh
- DUA = Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F = 0.75<sup>2</sup>
- Area = Square footage of insulated area
- $\eta_{\text{cool}}$  = Efficiency of air conditioning equipment (SEER), site specific
- CDH = Cooling Degree Hours; dependent on location, see table below
- kW/kWh<sub>cool</sub> = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

*Hours:*

Heating hours are characterized by the heating degree days for the facility.<sup>3</sup> The heating degree days are looked up based on the nearest weather station to the customer, as selected by the program vendor.

| <b>TMY3 City</b>         | <b>HDD</b> | <b>CDH</b> |
|--------------------------|------------|------------|
| Barnstable Muni Boa      | 4,379      | 1,349      |
| Beverly Muni             | 5,329      | 3,432      |
| Boston Logan Int'l Arpt  | 4,550      | 4,329      |
| Chicopee Falls Westo     | 5,016      | 4,116      |
| Lawrence Muni            | 4,640      | 3,978      |
| Martha's Vineyard        | 4,312      | 1,345      |
| Nantucket Memorial AP    | 3,988      | 362        |
| New Bedford Rgnl         | 4,434      | 4,232      |
| North Adams              | 5,234      | 2,524      |
| Norwood Memorial         | 4,872      | 4,763      |
| Otis ANGBb               | 4,718      | 2,588      |
| Plymouth Municipal       | 4,559      | 2,138      |
| Provincetown (AWOS)      | 4,368      | 2,195      |
| Westfield Barnes Muni AP | 5,301      | 3,784      |
| Worcester Regional Arpt  | 5,816      | 1,753      |

### Baseline Efficiency:

The baseline efficiency case is the existing conditions of the participating household.

For high rise the baseline efficiency case is characterized by the total R-value of the existing attic, basement or sidewall (Rexist). This is calculated as the R-value of the existing insulation, estimated by the program contractor, plus the R-value of the ceiling, floor, or wall (R-Assembly for all projects : RCEILING = 3.36; RFLOOR = 6.16; RWALL = 6.65).<sup>4</sup>

### High Efficiency:

The high efficiency case is characterized by the total R-value of the installation of additional attic, basement or sidewall insulation. This is calculated as the sum of the existing R-value (Rexist) plus the R-value of the added insulation.

### Measure Life:

The measure life is 25 years.<sup>5</sup>

| <b>Measure Name</b> | <b>Core Initiative</b> | <b>PA</b> | <b>EUL</b> | <b>OYF</b> | <b>RUL</b> | <b>AML</b> |
|---------------------|------------------------|-----------|------------|------------|------------|------------|
| Insulation          | RES_CD                 | All       | 25         | n/a        | n/a        | 25         |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

Moderate Income Qualified use the same impact factors

| Measure Name                                                           | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------------------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Insulation, Electric (Single Family)                                   | RES_CD          | National Grid | 1.00 | 0.56            | 1.00             | 0.56             | 0.56             | 0.00             | 0.43             |
| Insulation, Gas (Single Family)                                        | RES_CD          | National Grid | 1.00 | 1.00            | 0.75             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Oil (Single Family)                                        | RES_CD          | National Grid | 1.00 | 1.00            | 0.77             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Other (Single Family)                                      | RES_CD          | National Grid | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Electric (Attached Low Rise)                               | RES_CD          | National Grid | 1.00 | 0.56            | 1.00             | 0.56             | 0.56             | 0.00             | 0.43             |
| Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise) | RES_CD          | National Grid | 1.00 | 0.56            | 1.00             | 0.56             | 0.56             | 0.35             | 0.00             |
| Insulation, Gas (Attached Low Rise)                                    | RES_CD          | National Grid | 1.00 | 1.00            | 0.75             | 1.00             | 1.00             | 0.34             | 0.21             |
| Insulation, Oil (Attached Low Rise)                                    | RES_CD          | National Grid | 1.00 | 1.00            | 0.77             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Other (Attached Low Rise)                                  | RES_CD          | National Grid | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Electric (Single Family)                                   | RES_CD          | Eversource    | 1.00 | 0.56            | 1.00             | 0.56             | 0.56             | 0.00             | 0.43             |
| Insulation, Gas (Single Family)                                        | RES_CD          | Eversource    | 1.00 | 1.00            | 0.75             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Oil (Single Family)                                        | RES_CD          | Eversource    | 1.00 | 1.00            | 0.77             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Other (Single Family)                                      | RES_CD          | Eversource    | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Insulation, Electric (Attached Low Rise)                               | RES_CD          | Eversource    | 1.00 | 0.56            | 1.00             | 0.56             | 0.56             | 0.00             | 0.43             |
| Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise) | RES_CD          | Eversource    | 1.00 | 0.56            | 1.00             | 0.56             | 0.56             | 0.50             | 0.00             |

|                                                                        |        |            |      |      |      |      |      |      |      |
|------------------------------------------------------------------------|--------|------------|------|------|------|------|------|------|------|
| Insulation, Gas (Attached Low Rise)                                    | RES_CD | Eversource | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Oil (Attached Low Rise)                                    | RES_CD | Eversource | 1.00 | 1.00 | 0.77 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Other (Attached Low Rise)                                  | RES_CD | Eversource | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Electric (Single Family)                                   | RES_CD | Unitil     | 1.00 | 0.54 | 1.00 | 0.54 | 0.54 | 0.00 | 0.43 |
| Insulation, Gas (Single Family)                                        | RES_CD | Unitil     | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Oil (Single Family)                                        | RES_CD | Unitil     | 1.00 | 1.00 | 0.79 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Other (Single Family)                                      | RES_CD | Unitil     | 1.00 | 1.00 | 0.89 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Electric (Attached Low Rise)                               | RES_CD | Unitil     | 1.00 | 0.54 | 1.00 | 0.54 | 0.54 | 0.00 | 0.43 |
| Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise) | RES_CD | Unitil     | 1.00 | 0.54 | 1.00 | 0.54 | 0.54 | 0.50 | 0.00 |
| Insulation, Gas (Attached Low Rise)                                    | RES_CD | Unitil     | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Oil (Attached Low Rise)                                    | RES_CD | Unitil     | 1.00 | 1.00 | 0.79 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Other (Attached Low Rise)                                  | RES_CD | Unitil     | 1.00 | 1.00 | 0.89 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Electric (Single Family)                                   | RES_CD | CLC        | 1.00 | 0.54 | 1.00 | 0.54 | 0.54 | 0.00 | 0.43 |
| Insulation, Gas (Single Family)                                        | RES_CD | CLC        | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Oil (Single Family)                                        | RES_CD | CLC        | 1.00 | 1.00 | 0.79 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Other (Single Family)                                      | RES_CD | CLC        | 1.00 | 1.00 | 0.89 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Electric (Attached Low Rise)                               | RES_CD | CLC        | 1.00 | 0.56 | 1.00 | 0.56 | 0.56 | 0.00 | 0.43 |
| Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise) | RES_CD | CLC        | 1.00 | 0.54 | 1.00 | 0.54 | 0.54 | 0.50 | 0.00 |
| Insulation, Gas (Attached Low Rise)                                    | RES_CD | CLC        | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Oil (Attached Low Rise)                                    | RES_CD | CLC        | 1.00 | 1.00 | 0.79 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Other (Attached Low Rise)                                  | RES_CD | CLC        | 1.00 | 1.00 | 0.89 | 1.00 | 1.00 | 0.24 | 0.25 |

|                                                                |        |           |      |      |      |      |      |      |      |
|----------------------------------------------------------------|--------|-----------|------|------|------|------|------|------|------|
| Insulation, Gas (Single Family)                                | RES_CD | Berkshire | 1.00 | 1.00 | 0.83 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Gas (Attached Low Rise)                            | RES_CD | Berkshire | 1.00 | 1.00 | 0.83 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Gas (Single Family)                                | RES_CD | Columbia  | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Gas (Attached Low Rise)                            | RES_CD | Columbia  | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Gas (Single Family)                                | RES_CD | Liberty   | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Gas (Attached Low Rise)                            | RES_CD | Liberty   | 1.00 | 1.00 | 0.68 | 1.00 | 1.00 | 0.24 | 0.25 |
| Insulation, Electric (High Rise)                               | RES_CD | All       | 1.00 | 0.86 | n/a  | 0.86 | 0.86 | 0.00 | 0.43 |
| Insulation, Central AC in Electrically-Heated Unit (High Rise) | RES_CD | All       | 1.00 | 0.86 | n/a  | 0.86 | 0.86 | 0.50 | 0.00 |
| Insulation, Gas (High Rise)                                    | RES_CD | All       | 1.00 | n/a  | 0.86 | n/a  | n/a  | n/a  | n/a  |
| Insulation, Oil (High Rise)                                    | RES_CD | All       | 1.00 | n/a  | 0.86 | n/a  | n/a  | n/a  | n/a  |
| Insulation, Other (High Rise)                                  | RES_CD | All       | 1.00 | n/a  | 0.86 | n/a  | n/a  | n/a  | n/a  |

**In-Service Rates:**

All installations have 100% in service rate since all PA programs include verification of installations.

**Realization Rates:**

Realization rates are based on evaluation results.<sup>6 7</sup>

**Coincidence Factor:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>8</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are based on evaluation results.<sup>9</sup>

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Insulation, Electric (Single Family)     | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Insulation, Gas (Single Family)          | RES_CD          | All | 0.19 | 0.12            | 0.04             | 0.97 |
| Insulation, Oil (Single Family)          | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Insulation, Other (Single Family)        | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |
| Insulation, Electric (Attached Low Rise) | RES_CD          | All | 0.12 | 0.12            | 0.04             | 1.04 |



|                                                                        |        |     |      |      |      |      |
|------------------------------------------------------------------------|--------|-----|------|------|------|------|
| Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise) | RES_CD | All | 0.12 | 0.12 | 0.04 | 1.04 |
| Insulation, Gas (Attached Low Rise)                                    | RES_CD | All | 0.19 | 0.12 | 0.04 | 0.97 |
| Insulation, Oil (Attached Low Rise)                                    | RES_CD | All | 0.12 | 0.12 | 0.04 | 1.04 |
| Insulation, Other (Attached Low Rise)                                  | RES_CD | All | 0.12 | 0.12 | 0.04 | 1.04 |
| Insulation (High Rise)                                                 | RES_CD | All | 0.14 | 0.00 | 0.00 | 0.86 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Insulation (Single Family)     | RES_CD          | All | \$47.31            | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Insulation (Attached Low Rise) | RES_CD          | All | \$47.31            | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Insulation (High Rise)         | RES_CD          | All | \$47.31            | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |

### Endnotes:

- 1 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 2 : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 3 : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 4 : Assumptions from National Grid program vendor.
- 5 : GDS Associates (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 6 : Single Family and Attached Low Rise: Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. [2018 Navigant HES Impact Evaluation](#)
- 7 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 8 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 9 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Workbook [2021 Guidehouse MA Res NTG Final Results Workbook](#)

## 1.10. Building Shell - Window

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | RES-BS-WIN        |
| <b>Market</b>       | Residential       |
| <b>Program Type</b> | Early Replacement |
| <b>Category</b>     | Building Envelope |

### Measure Description:

Early replacement of a single pane window either with or without a storm with a triple pane window.

### BCR Measure IDs:

| Measure Name                 | Core Initiative                 | BCR Measure ID |
|------------------------------|---------------------------------|----------------|
| Window - Electric Resistance | Residential Retail (RES_RETAIL) | EA2c344        |
| Window - Heat Pump           | Residential Retail (RES_RETAIL) | EA2c345        |
| Window - Gas                 | Residential Retail (RES_RETAIL) | GA2c078        |
| Window - Oil                 | Residential Retail (RES_RETAIL) | EA2c346        |
| Window - Propane             | Residential Retail (RES_RETAIL) | EA2c347        |

### Algorithms for Calculating Primary Energy Impact:

Savings are calculated using the installed area of the replacement window and usage factors develop using RESFEN<sup>1</sup> to model different window types and heating fuels. The results of this analysis are shown in the 'Annual Energy Usage' table below, which provides the annual usage based by window type. Since this is an early replacement measure it is assumed that for one-third of the measure life the savings are calculated as the difference between the existing conditions and a triple pane window and for the remaining two-thirds of the measure life the savings are calculated as the difference between an ENERGY STAR double pane and ENERGY STAR triple pane window. The savings are deemed by heating fuel type per window based on the following table.

| Heating Fuel Type                    | Gross Annual kWh Saved | Maximum Load Reduction (kW) | Savings (MMBtu / Year) |
|--------------------------------------|------------------------|-----------------------------|------------------------|
| Window - Electric Resistance Heating | 131                    | 0.13                        | -                      |
| Window - Heat Pump*                  | 69                     | 0.05                        | -                      |
| Window - Gas Heating                 | 7                      | 0.01                        | 0.6                    |
| Window - Oil/Propane Heating         | 7                      | 0.01                        | 0.6                    |

\* Heat pump savings are assumed to be half of the electric resistance savings.

The early replacement remaining life heating savings were calculated as consumption of the existing window minus consumption of the Energy Star triple pane window where the final savings apply a 30.9% weight to the single pane 'tight' window and a 60.1% weight to the single pane with storm window (based on National Grid home energy assessment data). The savings are calculated as follows:

Single Pane 'tight' electric resistance heating savings are calculated using the following:

$$(AEHb-AEHes3)*SqFt = 215 \text{ kWh}$$

Single Pane with storm electric resistance heating savings are calculated using the following:

$$(AEHb2-AEHes3)*SqFt = 83.7 \text{ kWh}$$

Single Pane 'tight' fossil fuel heating savings are calculated using the following:

$$(AGUb-AGUes3)*SqFt = 1.08 \text{ MMBtu}$$

Single Pane with storm fossil fuel heating savings are calculated using the following:

$$(AGUb2-AGUes3)*SqFt = 0.42 \text{ MMBtu}$$

where:

$$AEHb=22.02 \text{ (see Annual Energy Usage table)}$$

$$AEHb2=10.79 \text{ (see Annual Energy Usage table)}$$

$$AEHes3=3.64 \text{ (see Annual Energy Usage table)}$$

$$AGUb=0.111 \text{ (see Annual Energy Usage table)}$$

$$AGUb2=0.054 \text{ (see Annual Energy Usage table)}$$

$$AGUes3=0.018 \text{ (see Annual Energy Usage table)}$$

$$SqFt= \text{Assumed } 11.7 \text{ square feet of area per window based on an average window size of } 31.5" \times 53.5"$$

The heating savings after the remaining life were calculated as consumption of the Energy Star double pane window (standard device) minus consumption of the Energy Star triple pane window. The savings are calculated as follows:

Energy Star double pane electric resistance heating savings are calculated using the following:

$$(AEHes2-AEHes3)*SqFt = 23.7 \text{ kWh}$$

Energy Star double pane fossil fuel heating savings are calculated using the following:

$$(AGUes2-AGUes3)*SqFt = 0.12 \text{ MMBtu}$$

where:

$$AEHes2=5.66 \text{ (see Annual Energy Usage table)}$$

$$AEHes3=3.64 \text{ (see Annual Energy Usage table)}$$

$$AGUes2=0.028 \text{ (see Annual Energy Usage table)}$$

$$AGUes3=0.018 \text{ (see Annual Energy Usage table)}$$

$$SqFt= \text{Assumed } 11.7 \text{ square feet of area per window based on an average window size of } 31.5" \times 53.5"$$

The cooling savings are weighted assuming that 34% of homes have central cooling and 53% of homes have window ACs.<sup>2</sup> The window AC savings are assumed to be 28.3% of the central cooling savings<sup>3</sup> calculated as follows:

Cooling early replacement savings are calculated using the following:  $(AECb2-AECes3)*SqFt = 14.27 \text{ kWh}$

Cooling savings after the remaining life are calculated using the following:  $(AECes2-AECes3)*SqFt = 1.64 \text{ kWh}$

$$AECb2=2.57 \text{ (see Annual Energy Usage table)}$$

$$AECes2=1.49 \text{ (see Annual Energy Usage table)}$$

$$AECes3=1.35 \text{ (see Annual Energy Usage table)}$$

$$SqFt= \text{Assumed } 11.7 \text{ square feet of area per window based on an average window size of } 31.5" \times 53.5"$$

**Annual Energy Usage**

| Window /Sliding Glass Door Type    | Annual Electric Heating Usage AEH (kWh/ft <sup>5</sup> ) | Annual Electric Cooling Usage AEC (kWh/ft <sup>6</sup> ) | Annual Fossil Fuel Usage AGU (MMBtu/ft <sup>7</sup> ) |
|------------------------------------|----------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------|
| Single Pane ("tight")              | 22.02                                                    | 2.57                                                     | 0.11                                                  |
| Double Pane (or single with storm) | 10.79                                                    | 2.57                                                     | 0.05                                                  |
| ENERGY STAR - Double Pane          | 5.66                                                     | 1.49                                                     | 0.03                                                  |
| ENERGY STAR - Triple Pane          | 3.64                                                     | 1.35                                                     | 0.02                                                  |

**Baseline Efficiency:**

The baseline efficiency case is a single pane window with or without a storm.

**High Efficiency:**

The high efficiency case is an ENERGY STAR® qualified triple pane window.

**Measure Life:**

The measure life is 25 years.<sup>4</sup> Dual baseline savings were calculated and assumed that the remaining life of the existing windows would be 1/3rd of the 25 year measure life or 8 years. Savings after the remaining life of the existing windows are assumed to be 2/3rd of the 25 year measure life or 17 years. The adjusted measure life (AML) was calculated by dividing calculated lifetime savings by annual savings.

| Measure Name                         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Window - Electric Resistance Heating | RES_RETAIL      | All | 25  | n/a | 8   | 14  |
| Window - Heat Pump                   | RES_RETAIL      | All | 25  | n/a | 8   | 13  |
| Window - Gas Heating                 | RES_RETAIL      | All | 25  | n/a | 8   | 14  |
| Window - Oil/Propane Heating         | RES_RETAIL      | All | 25  | n/a | 8   | 14  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Window - Electric Resistance Heating | RES_RETAIL      | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.06             | 0.13             |
| Window - Heat Pump                   | RES_RETAIL      | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.24             | 0.25             |

|                              |            |     |      |      |     |      |      |      |      |
|------------------------------|------------|-----|------|------|-----|------|------|------|------|
| Window - Gas Heating         | RES_RETAIL | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | 0.50 | 0.04 |
| Window - Oil/Propane Heating | RES_RETAIL | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | 0.50 | 0.04 |

**In-Service Rates:**

The in-service rate is assumed to be 100%.

**Realization Rates:**

Realization rates are based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Assumed 4% free-ridership based on the low market share of triple pane windows.

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Window       | RES_RETAIL      | All | 0.04 | 0.00            | 0.00             | 0.96 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>6</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Window       | RES_RETAIL      | All | \$6.72             | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |

**Endnotes:**

1 : Lawrence Berkeley National Laboratory, RESFEN 5.0 computer software, May 12, 2005.

<http://windows.lbl.gov/software>.

2 : Guidehouse (2020). Residential Baseline Study Phase 4. [2020 Guidehouse Residential Baseline Phase 4](#)

3 : Nexant Market Research Inc. (2007). Market Assessment for ENERGY STAR Room Air Conditioners in Connecticut.

4 : GDS Associates (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

5 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

6 : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.

[Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

## 1.11. Cooking – Induction Stove

|                     |                        |
|---------------------|------------------------|
| <b>Measure Code</b> | RES-FS-ISP             |
| <b>Market</b>       | Residential            |
| <b>Program Type</b> | Lost Opportunity       |
| <b>Category</b>     | Food Service Equipment |

### Measure Description:

Rebate provided for the purchase of a propane induction stove.

### BCR Measure IDs:

| Measure                   | Core Initiative                 | BCR Measure ID |
|---------------------------|---------------------------------|----------------|
| Induction Stove (Propane) | Residential Retail (RES_RETAIL) | EA2c352        |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh savings are deemed.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name              | Core Initiative | $\Delta$ kWh | $\Delta$ kW |
|---------------------------|-----------------|--------------|-------------|
| Induction Stove (Propane) | RES_RETAIL      | -258         | -0.04       |

### Baseline Efficiency:

The baseline efficiency case for the induction stove is a propane gas range.

### High Efficiency:

The high efficiency case is an electric induction stove.

### Measure Life:

The measure life is shown below.<sup>3</sup>

| Measure Name              | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------|-----------------|-----|-----|-----|-----|-----|
| Induction Stove (Propane) | RES_RETAIL      | All | 16  | n/a | n/a | 16  |

**Other Resource Impacts:**

| Measure Name              | Core Initiative | PA  | Propane (MMBTUs) <sup>4</sup> |
|---------------------------|-----------------|-----|-------------------------------|
| Induction Stove (Propane) | RES_RETAIL      | All | 2.10                          |

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name              | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Induction Stove (Propane) | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.85             | 0.65             |

**In-Service Rates:**

The in-service rate is assumed to be 100% absent evaluation.

**Realization Rates:**

The realization rate is assumed to be 100% absent evaluation.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------|-----------------|-----|------|-----------------|------------------|------|
| Induction Stove (Propane) | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts for this measure.

**Endnotes:**

- 
- 1 : Frontier Energy (2019). Residential Cooktop Performance and Energy Comparison Study. [2019 Frontier Energy Residential Cooktop Performance and Energy Comparison Study](#)
  - 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
  - 3 : Frontier Energy (2019). Residential Cooktop Performance and Energy Comparison Study. [2019 Frontier Energy Residential Cooktop Performance and Energy Comparison Study](#)
  - 4 : Frontier Energy (2019). Residential Cooktop Performance and Energy Comparison Study. [2019 Frontier Energy Residential Cooktop Performance and Energy Comparison Study](#)
  - 5 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.12. Custom - Residential Multi-Family

|                     |              |
|---------------------|--------------|
| <b>Measure Code</b> | RES-CM-CMRCD |
| <b>Market</b>       | Residential  |
| <b>Program Type</b> | Retrofit     |
| <b>Category</b>     | Custom       |

### Measure Description:

Vendors install a variety of electric and gas measures. The measures covered in this entry are associated with commercial gas and electric meters. Measures include HVAC, process, and domestic hot water equipment measures.

### BCR Measure IDs:

| Measure Name           | Core Initiative                           | BCR Measure ID |
|------------------------|-------------------------------------------|----------------|
| Custom - HVAC          | Residential Coordinated Delivery (RES_CD) | EA2a272        |
| Custom - Water Heating | Residential Coordinated Delivery (RES_CD) | EA2a273        |
| Custom - Process       | Residential Coordinated Delivery (RES_CD) | EA2a251        |
| Custom - CHP           | Residential Coordinated Delivery (RES_CD) | EA2a252        |
| Custom - Other         | Residential Coordinated Delivery (RES_CD) | EA2a253        |
| Custom - Heating       | Residential Coordinated Delivery (RES_CD) | GA2a094        |
| Custom - Process       | Residential Coordinated Delivery (RES_CD) | GA2a095        |
| Custom - Water Heating | Residential Coordinated Delivery (RES_CD) | GA2a096        |

### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings estimates for custom RCD projects are calculated by approved vendors with project-specific details. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis.

### Baseline Efficiency:

For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

### High Efficiency:

The high efficiency scenario is specific to the facility and may include one or more energy efficiency measures.



**Measure Life:**

| Measure Name                            | Core Initiative | PA        | EUL    | OYF | RUL | AML    |
|-----------------------------------------|-----------------|-----------|--------|-----|-----|--------|
| Custom - HVAC                           | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Custom - Water Heating                  | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Custom - Process                        | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Custom - CHP                            | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Custom - Other                          | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Heating, Gas - Custom (High Rise)       | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Process, Gas - Custom (High Rise)       | RES_CD          | Statewide | custom | n/a | n/a | custom |
| Water Heating, Gas - Custom (High Rise) | RES_CD          | Statewide | custom | n/a | n/a | custom |

**Other Resource Impacts:**

Other resource impacts are determined on a case by case basis.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Custom - HVAC                           | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - Water Heating                  | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - Process                        | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - CHP                            | RES_CD          | All | 1.00 | 1.10            | 1.22             | 1.44             | 1.01             | 0.00             | 0.43             |
| Custom - Other                          | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Heating, Gas - Custom (High Rise)       | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | n/a              | n/a              |
| Process, Gas - Custom (High Rise)       | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | n/a              | n/a              |
| Water Heating, Gas - Custom (High Rise) | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in-service rates since all PA programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on an evaluation study.<sup>1</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>2</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-gross factors are based on evaluation results.<sup>3</sup>

| Measure Name          | Core Initiative | PA        | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------|-----------------|-----------|------|-----------------|------------------|------|
| All Measures - Custom | RES_CD          | Statewide | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>4</sup>

| Measure Name                            | Core Initiative | PA        | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------|-----------------|-----------|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| HVAC- Custom                            | RES_CD          | Statewide |                    |                      | \$0.051           |                     |                     |                       |
| Water Heating - Custom                  | RES_CD          | Statewide |                    |                      | \$0.065           |                     |                     |                       |
| Process - Custom                        | RES_CD          | Statewide |                    |                      | \$0.098           |                     |                     |                       |
| CHP                                     | RES_CD          | Statewide |                    |                      | \$0.098           |                     |                     |                       |
| Other - Custom                          | RES_CD          | Statewide |                    |                      | \$0.098           |                     |                     |                       |
| Heating, Gas - Custom (High Rise)       | RES_CD          | Statewide |                    |                      |                   |                     | (\$0.037)           |                       |
| Process, Gas - Custom (High Rise)       | RES_CD          | Statewide |                    |                      |                   |                     | (\$0.045)           |                       |
| Water Heating, Gas - Custom (High Rise) | RES_CD          | Statewide |                    |                      |                   |                     | \$0.349             |                       |

**Endnotes:**

1 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

3 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

4 : NMR Group, Inc. (2021). C&I O&M and Non-O&M Non-Energy Impacts Study [2021 NMR CIOM and NonOM NEI Study](#)

## 1.13. Demand - Active Demand Reduction

|                     |                        |
|---------------------|------------------------|
| <b>Measure Code</b> | RES-DR-ADR             |
| <b>Market</b>       | Residential            |
| <b>Program Type</b> | Active Demand Response |
| <b>Category</b>     | Custom                 |

### Measure Description:

The core model for the Residential Direct Load Control offering is focused on reducing demand during summer peak load. The design is a bring-your-own-device model, starting first with communicating thermostats controlling central air conditioning units and cooling loads. Additional eligible connected devices may include water heaters, pool pumps, and other devices. Program Administrators, through the demand response management platform, send a signal to the device during an event that causes the controller to reduce the demand of the connected device. Events are called in the summer (June - September) during afternoon and evening hours. Customers can opt-out of events; however, they may be removed from the program if they regularly do not participate. Program Administrators will seek to enroll both customers with devices already installed and customers installing devices through the energy efficiency delivery pathways during the 2019-2021 plan period.

Under the Residential Storage Performance offering, customers are incentivized to decrease demand through the discharge of energy from storage in response to a signal or communication from the Program Administrators during daily peak hours in the summer and some targeted hours in winter months.

### BCR Measure IDs:

| Measure Name                                                   | Core Initiative                               | BCR Measure ID |
|----------------------------------------------------------------|-----------------------------------------------|----------------|
| Direct Load Control                                            | Residential Active Demand Reduction (RES_ADR) | EA2e001        |
| Battery Storage Daily Dispatch, discharge (savings) Summer     | Residential Active Demand Reduction (RES_ADR) | EA2e003        |
| Battery Storage Daily Dispatch, charge (consumption) Summer    | Residential Active Demand Reduction (RES_ADR) | EA2e011        |
| Battery Storage Targeted Dispatch, discharge (savings) Winter  | Residential Active Demand Reduction (RES_ADR) | EA2e004        |
| Battery Storage Targeted Dispatch, charge (consumption) Winter | Residential Active Demand Reduction (RES_ADR) | EA2e012        |
| Solar Inverter                                                 | Residential Active Demand Reduction (RES_ADR) | EA2e008        |
| EV Load Management (Summer)                                    | Residential Active Demand Reduction (RES_ADR) | EA2e005        |

|                             |                                               |         |
|-----------------------------|-----------------------------------------------|---------|
| EV Load Management (Winter) | Residential Active Demand Reduction (RES_ADR) | EA2e006 |
|-----------------------------|-----------------------------------------------|---------|

**Algorithms for Calculating Primary Energy Impact:**

For Direct Load Control, Initial savings are based on vendor estimates, which are then adjusted by hourly load adjustment factors described below in the Impact Factors for Calculating Adjusted Gross Savings section.

For Summer Storage Daily Dispatch, unit savings are deemed based on study results.<sup>1</sup>

For Winter Storage Daily Dispatch, unit savings are deemed based on study results.<sup>2</sup>

| PA                     | kW Savings per Battery* |
|------------------------|-------------------------|
| National Grid - Summer | 5.5                     |
| National Grid - Winter | 6.9                     |
| Unitil - Summer        | 1.3                     |
| Unitil - Winter        | 8.3                     |

\* Savings per battery represent the average demand savings (which is equivalent to the battery discharge) during events for batteries that successfully participated.

**Baseline Efficiency:**

For Direct Load Control, evaluators determined baseline conditions using an experimental design methodology (randomly assigned treatment and control groups), or a within-subject methodology or savings adjustment factor for demand reduction events where experimental design was not possible.<sup>3</sup>

For Storage Daily Dispatch, demand and energy impacts of the energy storage are measured assuming the whole-home and solar PV data as the baseline.<sup>4, 5</sup>

**High Efficiency:**

N/A, Active Demand Reduction does not directly increase efficiency. Direct load control does reduce energy consumption by curtailing use, but does not increase efficiency per se. Storage increases energy consumption due to round trip efficiency losses.

**Measure Life:**

Because Active Demand Reduction is based on Program Administrators calling demand reduction events each year, the measure life is one year.

| Measure Name                         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------|-----------------|-----|-----|-----|-----|-----|
| All Active Demand Reduction measures | RES_ADR         | All | 1   | n/a | n/a | 1   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

To date only the Direct Load Control (DLC) and Storage Daily Dispatch offers have been evaluated. For other offers, realization rates and coincidence factors are assumed to be 1.0 until evaluation results are available.

For the DLC offer, realization rates are set to 100% because hourly load adjustment factors, based on evaluation results, are used instead. Evaluators determined hourly load adjustment factors to adjust vendor-reported demand reduction based on evaluated results. The hourly load adjustment factor is 0.72 during the pre-cooling period and 0.68 during the recovery period. During the event, the hourly load adjustment factor is a function of temperature, equal to  $-3.06 + (0.05 \times \text{Average Temperature } ^\circ\text{F})$ . This calculation applies under the following conditions: when the ISO-NE or PJM baseline is used, the event duration is three hours, the assumed air conditioning nameplate capacity continues to be 3.5 kW, and the average outdoor temperature is 75 degrees F or higher.<sup>6</sup> Benefits are calculated based on adjusted demand reduction during the peak hour of each of the 62 days in July and August. This generates an average curtailment amount and a limited scaling factor that are used to calculate demand reduction benefits.

For Storage Daily Dispatch, realization rates are set to 100% since deemed savings are based on evaluation results.<sup>7, 8</sup>

| Measure Name                                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Direct Load Control                                    | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| Storage Daily Dispatch, discharge (savings) Summer     | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| Storage Daily Dispatch, charge (consumption) Summer    | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| Storage Targeted Dispatch, discharge (savings) Winter  | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 1.00             |
| Storage Targeted Dispatch, charge (consumption) Winter | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| EV Load Management, Discharge (Summer)                 | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| EV Load Management, Charge (Summer)                    | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| EV Load Management, Discharge (Winter)                 | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 1.00             |
| EV Load Management, Charge (Winter)                    | RES_ADR         | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |

## Impact Factors for Calculating Net Savings:

Statewide Active Demand Reduction offerings are new in 2019 and have not yet been evaluated. Net-to-gross ratios are assumed to be 1.0 until the statewide program is evaluated.

| Measure Name                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| All Active Demand Reduction measures | RES_ADR         | All | 0.00 | 0.00            | 0.00             | 1.00 |

## Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

## Endnotes:

- 1 : Guidehouse (2020). 2019 Residential Energy Storage Demand Response Demonstration Evaluation: Summer Season [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 2 : Guidehouse (2020). 2019/20 Residential Energy Storage Demand Response Demonstration Evaluation: Winter Season [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)
- 3 : Guidehouse (2020). 2019 Residential Wi-Fi Thermostat Direct Load Control Offering Evaluation [2019 Guidehouse Residential Wi-Fi Thermostat DLC](#)
- 4 : Guidehouse (2020). 2019 Residential Energy Storage Demand Response Demonstration Evaluation: Summer Season [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 5 : Guidehouse (2020). 2019/20 Residential Energy Storage Demand Response Demonstration Evaluation: Winter Season [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)
- 6 : Guidehouse (2020). 2019 Residential Wi-Fi Thermostat Direct Load Control Offering Evaluation [2019 Guidehouse Residential Wi-Fi Thermostat DLC](#)
- 7 : Guidehouse (2020). 2019 Residential Energy Storage Demand Response Demonstration Evaluation: Summer Season [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 8 : Guidehouse (2020). 2019/20 Residential Energy Storage Demand Response Demonstration Evaluation: Winter Season [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)

## 1.14. HVAC - Air Source Central Heat Pump

|                     |                                                |
|---------------------|------------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-ASHP                                  |
| <b>Market</b>       | Residential                                    |
| <b>Program Type</b> | Early Retirement, Replace on Burnout, Retrofit |
| <b>Category</b>     | Heating Ventilation and Air Conditioning       |

### Measure Description:

The installation of high efficiency air source, central heat pump systems.

### BCR Measure IDs:

| Measure Name                                                          | Core Initiative                 | BCR Measure ID |
|-----------------------------------------------------------------------|---------------------------------|----------------|
| Central Heat Pump, No Integrated Controls                             | Residential Retail (RES_RETAIL) | EA2c003        |
| Moderate Income Qualified - Central Heat Pump, No Integrated Controls | Residential Retail (RES_RETAIL) | EA2c314        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are based on a per ton using the following algorithms and assumptions and reflect a blend of replace on failure and early retirement for the Central Heat Pump, No Integrated Controls measure. For Moderate Income Qualified - Central Heat Pump, No Integrated Controls these savings are calculated as a retrofit baseline (Savings is based on existing equipment):

$$\Delta kWh_{\text{unit}} = \Delta kWh_{\text{cool}} + \Delta kWh_{\text{heat}} = [\text{Tons} * 12\text{kBtu/hr/Ton} * (1/\text{SEER}_{\text{BASE}} - 1/\text{SEER}_{\text{EE}}) * \text{HOURS}_{\text{C}}] +$$

$$[\text{Tons} * 12\text{kBtu/hr/Ton} * (1/\text{HSPF}_{\text{BASE}} - 1/\text{HSPF}_{\text{EE}}) * \text{HOURS}_{\text{H}}]$$

$$\Delta kW = \max(\Delta kW_{\text{cool}}, \Delta kW_{\text{heat}})$$

$$\Delta kW_{\text{cool}} = \Delta kWh_{\text{cool}} * \text{Annual Maximum Demand Factor (cool)}$$

$$\Delta kW_{\text{heat}} = \Delta kWh_{\text{heat}} * \text{Annual Maximum Demand Factor (heat)}$$

### Where:

Unit = Savings per outdoor unit

Tons = Capacity of HP equipment

SEER<sub>BASE</sub> = Seasonal Energy Efficiency Ratio of baseline HP equipment

SEER<sub>EE</sub> = Seasonal Energy Efficiency Ratio of new efficient HP equipment.

HSPF<sub>BASE</sub> = Heating Seasonal Performance Factor of baseline HP equipment

HSPF<sub>EE</sub> = Heating Seasonal Performance Factor of new efficient HP equipment.

Hours<sub>C</sub> = Equivalent Full Load Hours (EFLH) for cooling

Hours<sub>H</sub> = EFLH for heating

For replace on failure, unit savings are counted as the efficiency savings for the high efficiency heat pump unit compared to a code-compliant heat pump unit for the full life of the new high efficiency heat pump unit.

For early retirement of an existing heat pump unit, unit savings are counted in two parts: (1) early retirement savings for a code-compliant heat pump unit compared to the existing heat pump unit over the remaining life of the existing heat pump unit, and (2) efficiency savings for the high efficiency heat pump unit compared to a code-compliant heat pump unit for the full life of the new high efficiency heat pump unit.

The savings for this measure are blended 69.5% Replace on Failure and 31.5% Early Retirement.

**Savings for Residential Air-Source Heat Pumps <sup>1</sup>**

| Measure Name                                                          | Energy Type | Average SEER <sup>2</sup> | Average HSPF <sup>3</sup> | Tons | Hours <sup>2</sup>         | ΔkWh/Ton | Annual Max Demand Factor <sup>3</sup> | ΔkW  |
|-----------------------------------------------------------------------|-------------|---------------------------|---------------------------|------|----------------------------|----------|---------------------------------------|------|
| Central Heat Pump, No Integrated Controls                             | Electric    | 17.6                      | 9.81                      | 3.03 | 419 (cool)<br>1,200 (heat) | 1533     | 0.001117 (winter)                     | 1.80 |
| Moderate Income Qualified - Central Heat Pump, No Integrated Controls | Electric    | 17.6                      | 9.81                      | 3.03 | 419 (cool)<br>1,200 (heat) | 2445     | 0.001117 (winter)                     | 2.87 |

**Baseline Efficiency:**

**Central Heat Pump, No Integrated Controls**

For replace on failure, the baseline is a code-compliant SEER 14, HSPF 8.2 heat pump unit.

For early retirement, over the remaining life of the existing heat pump unit, the baseline is an existing inefficient SEER 10, HSPF 7 heat pump unit. For early retirement, over the life of the new heat pump, the baseline is a code-compliant SEER 14, HSPF 8.2 heat pump unit.

**Moderate Income Qualified - Central Heat Pump, No Integrated Controls**

The baseline is an existing central heat pump; SEER 10 and HSPF 7.

**High Efficiency:**

**Central Heat Pump, No Integrated Controls**

For replace on failure, the high efficiency case is a SEER 17.6, HSPF 9.8 heat pump unit, based on the efficiency levels of units rebated in the previous calendar year.

For early retirement, over the remaining life of the existing heat pump unit, the high efficiency case is a code-compliant SEER 14, HSPF 8.2 heat pump unit. For early retirement, over the life of the new heat pump, the high efficiency case is a SEER 17.6, HSPF 9.8 heat pump unit.

**Moderate Income Qualified - Central Heat Pump, No Integrated Controls**

The high efficiency case is a SEER 17.6, HSPF 9.8 heat pump unit.

**Measure Life:**



The measure life is based on evaluation results and a blend of replace on failure and early retirement.<sup>7</sup> The remaining life for the existing unit is 6 years, and the measure life of new equipment is 18 years. The blended measure life is 15 years.

| Measure Name                                                          | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Central Heat Pump, No Integrated Controls                             | RES_RETAIL      | All | 18  | n/a | 6   | 15  |
| Moderate Income Qualified - Central Heat Pump, No Integrated Controls | RES_RETAIL      | All | 18  | n/a | n/a | 18  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Central Heat Pump, No Integrated Controls                             | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.38             | 0.05             |
| Moderate Income Qualified - Central Heat Pump, No Integrated Controls | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.38             | 0.05             |

### In-Service Rates

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

### Realization Rates

Realization rates are set to 100% since deemed savings are based on evaluation results.

### Coincidence Factors

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

### Impact Factors for Calculating Net Savings:

Net-to-gross factors are based on evaluation results.

| Measure Name                                                                       | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Central Heat Pump, No Integrated Controls <sup>8</sup>                             | RES_RETAIL      | All | 0.34 | 0.12            | 0.10             | 0.88 |
| Moderate Income Qualified - Central Heat Pump, No Integrated Controls <sup>9</sup> | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

## Non-Energy Impacts:

NEI values are rolled up and reflect a blend of replace on failure and early retirement, component values can be found in Appendix B.<sup>9</sup>

| Measure Name                                                          | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Central Heat Pump, No Integrated Controls                             | RES_RETAIL      | All | \$8.11             | \$0.00               | \$0.00            | \$0.00              | n/a                 | n/a                   |
| Moderate Income Qualified - Central Heat Pump, No Integrated Controls | RES_RETAIL      | All | \$15.96            | \$0.00               | \$0.00            | \$0.00              | n/a                 | n/a                   |

## Endnotes:

**1** : Percentages of replace on failure and early retirement are from NMR Group (2018), Massachusetts Residential HVAC NTG and Market Effects Study (TXC34); and subsequently adjusted by 10% per agreement with EEAC consultants. The calculation of these percentages and unit savings can be found here. [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

**2** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study (cooling hours). [2018 Navigant Baseline Loadshape Comprehensive Report](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**7** : MA PAs (2021). 2022-2024 plan Electric HVAC Calculations Workbook. Measure life reflects a blend of replace on failure and early replacement. [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

**7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**8** : MA PAs (2021). 2022-2024 Electric HVAC Calculations Workbook. NTG factors reflect a blend of replace on failure NTG factors obtained from NMR Group (2018), Massachusetts Residential HVAC NTG and Market Effects Study and early retirement and NTG factors obtained from Navigant (2018) Heating and Cooling Early Retirement Net-to-Gross. The calculation of the blended NTG factors can be found in MA PAs (2021). 2022-2024 plan Electric HVAC Calculations Workbook. [2021 Guidehouse MA Res NTG Final Report](#)

**9** : An agreed upon assumption between the PAs and EEAC.

**9** : MA PAs (2021). 2022-2024 planning Electric HVAC Calculations Workbook. [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

## 1.15. HVAC - Boiler Reset Control

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-BSC                             |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.

### BCR Measure IDs:

| Measure Name                                | Core Initiative                           | BCR Measure ID |
|---------------------------------------------|-------------------------------------------|----------------|
| Room Response Boiler Reset Control, Propane | Residential Retail (RES_RETAIL)           | EA2c288        |
| Boiler Reset Control, Gas - Midstream       | Residential Retail (RES_RETAIL)           | EA2c276        |
| Boiler Reset Control, Oil - Midstream       | Residential Retail (RES_RETAIL)           | EA2c277        |
| Boiler Reset Control, Other - Midstream     | Residential Retail (RES_RETAIL)           | EA2c278        |
| Boiler Reset Control, Gas (Single Family)   | Residential Coordinated Delivery (RES_CD) | GA2a039        |
| Boiler Reset Control, Gas                   | Residential Retail (RES_RETAIL)           | GA2c021        |
| Room Response Boiler Reset Control          | Residential Retail (RES_RETAIL)           | GA1c035        |
| Boiler Reset Control, Gas - Midstream       | Residential Retail (RES_RETAIL)           | GA2c048        |

### Algorithms for Calculating Primary Energy Impact:

For standard boiler reset controls unit savings are deemed based on study results for all boiler reset controls.<sup>1</sup> A Boiler Reset Control is a device that automatically **controls the boiler** water temperature according to a software program based on outdoor temperature. The water can be run a little cooler during fall and spring, and a little hotter during the coldest parts of the winter. For Room Response boiler controls measures, savings are based on a 2.5 % savings estimate using the source: <sup>2</sup> A room response control reduces boiler energy usage by adjusting the boiler outlet water temperature based on the building's response time to achieve room setpoint temperatures. When the building calls for heat, a control automatically adjusts condensing boiler sending water temperatures to a minimum level while still providing sufficient heat to meet building load based on real time heating load from recent boiler cycles, increasing the efficiency of the boiler without requiring an outdoor air temperature sensor.

| Measure Name                                | $\Delta$ MMBtu |
|---------------------------------------------|----------------|
| Boiler Reset Control, Gas - Midstream       | 5.1            |
| Boiler Reset Control, Oil - Midstream       | 5.2            |
| Boiler Reset Control, Other - Midstream     | 5.1            |
| Boiler Reset Control, Gas (Single Family)   | 5.1            |
| Boiler Reset Control, Gas                   | 5.1            |
| Room Response Boiler Reset Control, Propane | 2.2            |
| Room Response Boiler Reset Control          | 2.2            |

### Baseline Efficiency:

The baseline efficiency case is a boiler without reset controls for all boiler reset controls. The baseline efficiency case for room response boiler reset control is a standard boiler reset control.

### High Efficiency:

The high efficiency case is a boiler with reset controls for all boiler reset control measures. For the room response boiler reset control measure the high efficiency case is a room response boiler reset control connected to a condensing boiler.

### Measure Life:

The measure life is 15 years.<sup>3</sup>

| Measure Name                                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Boiler Reset Control, Gas - Midstream       | RES_RETAIL      | All | 15  | n/a | n/a | 15  |
| Boiler Reset Control, Oil - Midstream       | RES_RETAIL      | All | 15  | n/a | n/a | 15  |
| Boiler Reset Control, Other - Midstream     | RES_RETAIL      | All | 15  | n/a | n/a | 15  |
| Boiler Reset Control, Gas (Single Family)   | RES_CD          | All | 15  | n/a | n/a | 15  |
| Boiler Reset Control, Gas                   | RES_RETAIL      | All | 15  | n/a | n/a | 15  |
| Room Response Boiler Reset Control, Propane | RES_RETAIL      | All | 15  | n/a | n/a | 15  |
| Room Response Boiler Reset Control          | RES_RETAIL      | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Boiler Reset Control, Gas - Midstream       | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Boiler Reset Control, Oil - Midstream       | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Boiler Reset Control, Other - Midstream     | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Boiler Reset Control, Gas (Single Family)   | RES_CD          | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Boiler Reset Control, Gas                   | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Room Response Boiler Reset Control, Propane | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Room Response Boiler Reset Control          | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

| Measure Name <sup>4</sup>                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Boiler Reset Control, Gas - Midstream       | RES_RETAIL      | All | 0.36 | 0.12            | 0.00             | 0.76 |
| Boiler Reset Control, Oil - Midstream       | RES_RETAIL      | All | 0.33 | 0.12            | 0.01             | 0.80 |
| Boiler Reset Control, Other - Midstream     | RES_RETAIL      | All | 0.33 | 0.12            | 0.01             | 0.80 |
| Boiler Reset Control, Gas (Single Family)   | RES_CD          | All | 0.36 | 0.12            | 0.00             | 0.76 |
| Boiler Reset Control, Gas                   | RES_RETAIL      | All | 0.36 | 0.12            | 0.00             | 0.76 |
| Room Response Boiler Reset Control, Propane | RES_RETAIL      | All | 0.33 | 0.12            | 0.01             | 0.80 |
| Room Response Boiler Reset Control          | RES_RETAIL      | All | 0.36 | 0.12            | 0.00             | 0.76 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

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**1** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.

[2018 Navigant HES Impact Evaluation](#)

**2** : This source recommends a 2.5% savings that is comparing a standard boiler reset control to the more advanced room to room controls. [Mass Save Residential Technology Energy Savings Submittal March 2019](#)

**3** : ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE. ACEEE\_2006\_Emerging\_Technologies\_Report\_Advanced\_Boiler\_Controls

**4** : NTG values were derived from the following study using the fuel specific NTG values (1 for gas and 1 for other fuels): [2021 Guidehouse MA Res NTG Final Report](#)

## 1.16. HVAC - CVEO Battery Storage Dispatch

|                     |                        |
|---------------------|------------------------|
| <b>Measure Code</b> | RES-HVAC-CVEO-BAT      |
| <b>Market</b>       | Residential            |
| <b>Program Type</b> | Active Demand Response |
| <b>Category</b>     | Other                  |

### BCR Measure IDs:

| Measure                                                             | Core Initiative                               | BCR Measure ID |
|---------------------------------------------------------------------|-----------------------------------------------|----------------|
| CVEO Battery Storage Daily Dispatch, discharge (savings) Summer     | Residential Active Demand Reduction (RES_ADR) | CVEO5          |
| CVEO Battery Storage Daily Dispatch, charge (consumption) Summer    | Residential Active Demand Reduction (RES_ADR) | CVEO6          |
| CVEO Battery Storage Targeted Dispatch, discharge (savings) Winter  | Residential Active Demand Reduction (RES_ADR) | CVEO7          |
| CVEO Battery Storage Targeted Dispatch, charge (consumption) Winter | Residential Active Demand Reduction (RES_ADR) | CVEO8          |

Under the Residential Storage Performance offering, customers are incentivized to decrease demand through the discharge of energy from storage in response to a signal. The measures in the CVEO initiative planned by CLC are consistent with the Statewide Residential Active Demand Core Initiative. CLC has not yet evaluated Battery Storage and plans to in the near future.

### Algorithms for Calculating Primary Energy Impact:

For Summer Storage Daily Dispatch, unit savings are deemed based on study results.1

For Winter Storage Daily Dispatch, unit savings are deemed based on study results.2

| PA                     | kW Savings per Battery* |
|------------------------|-------------------------|
| National Grid - Summer | 5.5                     |
| National Grid - Winter | 6.9                     |
| Unitil - Summer        | 1.3                     |
| Unitil - Winter        | 8.3                     |

\* Savings per battery represent the average demand savings (which is equivalent to the battery discharge) during events for batteries that successfully participated.

**Baseline Efficiency:**

For Storage Daily Dispatch, demand and energy impacts of the energy storage are measures assuming the whole-home and solar PV data as the baseline.<sup>3 4</sup>

**High Efficiency:**

N/A, Active Demand Reduction does not directly increase efficiency. Storage increases energy consumption due to round trip efficiency losses.

**Measure Life:**

Because Active Demand Reduction is based on Program Administrators calling demand reduction events each year, the measure life is one year.

| Measure Name         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------|-----------------|-----|-----|-----|-----|-----|
| CVEO Battery Storage | RES_ADR         | CLC | 1   | n/a | n/a | 1   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

For Storage Daily Dispatch, realization rates are set to 100% since deemed savings are based on evaluation results.<sup>5 6</sup>

| Measure Name                                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Storage Daily Dispatch, discharge (savings) Summer     | RES_ADR         | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| Storage Daily Dispatch, discharge (consumption) Summer | RES_ADR         | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| Storage Daily Dispatch, discharge (savings) Winter     | RES_ADR         | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 1.00             |
| Storage Daily Dispatch, discharge (consumption) Winter | RES_ADR         | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 1.00             |

**Impact Factors for Calculating Net Savings:**

Active Demand Reduction offerings are new and have not yet been evaluated. Net-to-gross ratios are assumed to be 1.0 until the statewide program is evaluated.

| Measure Name         | Core Initiative | PA  | FR   | SO <sub>p</sub> | SO <sub>NP</sub> | NTG  |
|----------------------|-----------------|-----|------|-----------------|------------------|------|
| CVEO Battery Storage | RES_ADR         | CLC | 0.00 | 0.00            | 0.00             | 1.00 |



**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

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- 1 : [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 2 : [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)
- 3 : [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 4 : [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)
- 5 : [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 6 : [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)

## 1.17. HVAC - CVEO Solar PV

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-CVEO-SOLPV                      |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Early Retirement                         |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### BCR Measure IDs:

| Measure       | Core Initiative                           | BCR Measure ID |
|---------------|-------------------------------------------|----------------|
| CVEO Solar PV | Residential Coordinated Delivery (RES_CD) | CVEO4          |

### Algorithms for Calculating Primary Energy Impact:

The annual energy (in kWh and kW) produced by the installed solar PV system, accounting for location, system size, system orientation, and capacity factor.

The kWh for a particular system can be estimated using the National Renewable Energy Laboratory (“NREL”) PVWatts Calculator, available at: <https://pvwatts.nrel.gov/>

### Baseline Efficiency:

No Solar PV

### High Efficiency:

Installation of Solar

### Measure Life:

The measure life for a new solar PV system is assumed to be 25 years, consistent with net metering credit availability in Massachusetts. See: <https://www.mass.gov/guides/net-metering-guide>.

| Measure Name  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------|-----------------|-----|-----|-----|-----|-----|
| CVEO Solar PV | Res_CD          | CLC | 25  | n/a | n/a | 25  |

### 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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| CVEO Solar PV | RES_CD          | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.80             | 0.00             |

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are set to 100% until an evaluation occurs.

| Measure Name  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------|-----------------|-----|------|-----------------|------------------|------|
| CVEO Solar PV | RES_CD          | CLC | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified with this measure.

## 1.18. HVAC - Central AC Quality Installation Verification (QIV)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-CACQIV                          |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

The verification of proper charge and airflow during installation of new central air conditioning (AC) system.

### BCR Measure IDs:

| Measure Name    | Core Initiative                 | BCR Measure ID |
|-----------------|---------------------------------|----------------|
| Central Air QIV | Residential Retail (RES_RETAIL) | EA2c104        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:<sup>1</sup>

$$\Delta kWh = \text{Tons} \times 12 \text{ kBtu/hr/Ton} \times (1/\text{SEER}) \times \text{Hours} \times 5\%$$

$$\Delta kW = \Delta kWh \times \text{Annual Maximum Demand Factor}$$

Where:

Unit = Completed QIV of new central air conditioning system

Tons = Cooling capacity of AC equipment

SEER = Seasonal Energy Efficiency Ratio of AC equipment

Hours = Equivalent Full Load Hours (EFLH)

5% = Average demand reduction of 5.0%<sup>2</sup>

### Savings for Central Air QIV

| Measure Name    | Energy Type | Average Capacity (tons) <sup>3</sup> | Average SEER <sup>4</sup> | Hours <sup>5</sup> | $\Delta kWh$ | Annual Max Demand Factor <sup>6</sup> | $\Delta kW$ |
|-----------------|-------------|--------------------------------------|---------------------------|--------------------|--------------|---------------------------------------|-------------|
| Central Air QIV | Electric    | 2.69                                 | 16.8                      | 419                | 40.3         | 0.00143                               | 0.06        |

### Baseline Efficiency:

The baseline efficiency case is a new central air conditioning system (2.69 -ton and SEER 16.8), based on the average capacity and efficiency level of units rebated in the previous calendar year (2020), whose installation is inconsistent with manufacturer specifications.

**High Efficiency:**

The high efficiency case is the same air conditioning system whose installation is consistent with manufacturer specifications.

**Measure Life:**

The measure life is based on evaluation results.<sup>7</sup>

| Measure Name    | Core Initiative    | PA  | EUL | OYF | RUL | AML |
|-----------------|--------------------|-----|-----|-----|-----|-----|
| Central Air QIV | RES_CD, RES_RETAIL | All | 18  | N/A | N/A | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name    | Core Initiative | PA  | ISR  | RRE  | RR <sub>NF</sub> | RRSP | RRWP | CFSP | CFWP |
|-----------------|-----------------|-----|------|------|------------------|------|------|------|------|
| Central Air QIV | RES_CD,         | All | 1.00 | 1.00 | 1.00             | 1.00 | 1.00 | 0.37 | 0.00 |

**In-Service Rates:**

All quality installation verifications are completed and documented and therefore have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>8</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------|-----------------|-----|------|-----------------|------------------|------|
| Central Air QIV | RES_RETAIL      | All | 0.34 | 0.12            | 0.10             | 0.88 |

**Non-Energy Impacts:**

NEI values are rolled up and reflect a blend of replace on failure and early retirement, component values can be found in Appendix B.

| Measure Name    | Core Initiative    | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------|--------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Central Air QIV | RES_CD, RES_RETAIL | All | \$1.53             |                      |                   |                     |                     |                       |

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**Endnotes:**

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**1** : The calculation of unit savings can be found in MA PAs' 2022-2024 Plan Electric Heating and Cooling Savings Workbook (2021). [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

**2** : Average capacity (tons) of central air conditioning units rebated in the full calendar year preceding the year in which this eTRM is published.

**3** : Average SEER of central air conditioning units rebated in the full calendar year preceding the year in which this eTRM is published.

**4** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study.

[2018 Navigant Baseline Loadshape Comprehensive Report](#)

**5** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study.

[2018 Navigant Baseline Loadshape Comprehensive Report](#)

**6** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**7** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**8** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.19. HVAC - Central Air Conditioning

|                     |                                                |
|---------------------|------------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-CAC                                   |
| <b>Market</b>       | Residential                                    |
| <b>Program Type</b> | Early Retirement, Replace on Burnout, Retrofit |
| <b>Category</b>     | Heating Ventilation and Air Conditioning       |

### Measure Description:

The installation of high efficiency central air conditioning (AC) systems.

### BCR Measure IDs:

| Measure Name                            | Core Initiative                 | BCR Measure ID |
|-----------------------------------------|---------------------------------|----------------|
| Central Air                             | Residential Retail (RES_RETAIL) | EA2c001        |
| Moderate Income Qualified - Central Air | Residential Retail (RES_RETAIL) | EA2c313        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions and reflect a blend of replace on failure and early retirement:

$$\Delta kWh = \text{Tons} * 12 \text{ kBtu/hr} / \text{Ton} \times (1/SEER_{BASE} - 1/SEER_{EE}) \times \text{Hours}$$

$$\Delta kW = \Delta kWh \times \text{Annual Maximum Demand Factor}$$

Where:

Tons = Cooling capacity of AC equipment

SEER<sub>BASE</sub> = Seasonal Energy Efficiency Ratio of baseline AC equipment

SEER<sub>EE</sub> = Seasonal Energy Efficiency Ratio of new efficient AC equipment.

Hours = Equivalent Full Load Hours (EFLH)

### Central Air

For replace on failure, unit savings are counted as the efficiency savings for the high efficiency air conditioning unit compared to an industry standard air conditioning unit for the full life of the new high efficiency air conditioning unit.

For early retirement of an existing air conditioning unit, unit savings are counted in two parts: (1) early retirement savings for an industry standard air conditioning unit compared to the existing air conditioning unit over the remaining life of the existing air conditioning unit, and (2) efficiency savings for the high efficiency air conditioning unit compared to a industry standard air conditioning unit for the full life of the new high efficiency air conditioning unit.

**Moderate Income Qualified - Central Air**

For retrofit of an existing air conditioning unit, unit savings are counted going from an industry standard air conditioning unit compared to the existing air conditioning unit .

**Savings for Residential Central Air Conditioners<sup>1</sup>**

| Measure Name                                                                          | Energy Type | Average SEER <sup>2</sup> | Hours <sup>3</sup> | Tons | ΔkWh | Annual Max Demand Factor <sup>4</sup> | ΔkW  |
|---------------------------------------------------------------------------------------|-------------|---------------------------|--------------------|------|------|---------------------------------------|------|
| Central Air<br>(Blended Savings, 60.5% Replace on Failure and 39.5% Early Retirement) | Electric    | 16.8                      | 419                | 2.7  | 223  | 0.00143                               | 0.32 |
| Moderate Income Qualified - Central Air                                               | Electric    | 16.8                      | 419                | 2.7  | 321  | 0.00143                               | 0.46 |

**Baseline Efficiency:**

**Central Air**

For replace on failure, the baseline is an industry standard, SEER 14 central air-conditioning unit.

For early retirement, over the remaining life of the existing air conditioning unit, the baseline is an existing SEER 12 central air-conditioning unit. For early retirement, over the life of the new air conditioner, the baseline is an industry standard, SEER 14 central air-conditioning unit.

**Moderate Income Qualified - Central Air**

For retrofit, the existing air conditioning unit is a baseline SEER 12 central air-conditioning unit.

**High Efficiency:**

**Central Air**

For replace on failure, the high efficiency case is a SEER 16.8 central air-conditioning unit, based on the average capacity and efficiency levels of units rebated in the previous calendar year.

For early retirement, over the remaining life of the existing air conditioning unit, the high efficiency case is an industry standard, SEER 14 central air-conditioning unit. For early retirement, over the life of the new air conditioner, the high efficiency case is a high efficiency SEER 16.8 central air-conditioning unit.

**Moderate Income Qualified - Central Air**

The high efficiency case is a SEER 16.8 central air-conditioning unit, based on the average capacity and efficiency levels of units rebated in the previous calendar year.



**Measure Life:**

**Central Air**

The measure life is based on evaluation results and a blend of replace on failure and early retirement.<sup>6</sup> The remaining life for the existing unit is 6 years, and the measure life of new equipment is 18 years. The blended measure life is 15 years.

**Moderate Income Qualified - Central Air**

The measure life is based on evaluation results and is set to 18 years.

| Measure Name                            | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Central Air                             | RES_RETAIL      | All | 18  | N/A | 6   | 15  |
| Moderate Income Qualified - Central Air | RES_RETAIL      | All | 18  | N/A | N/A | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Central Air                             | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |
| Moderate Income Qualified - Central Air | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Central Air <sup>8</sup>                             | RES_RETAIL      | All | 0.34 | 0.22            | 0                | 0.88 |
| Moderate Income Qualified - Central Air <sup>9</sup> | RES_RETAIL      | All | 0.00 | 0.00            | 0                | 1.00 |

## Non-Energy Impacts:

NEI values are rolled up and reflect a blend of replace on failure and early retirement, component values can be found in Appendix B.<sup>10</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Central Air  | RES RETAIL      | All | \$8.98             |                      |                   |                     |                     |                       |

## Endnotes:

**1** : Savings are documented in the following calculator. [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

**2** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study. [2018 Navigant Baseline Loadshape Comprehensive Report](#)

**3** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study. [2018 Navigant Baseline Loadshape Comprehensive Report](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**6** : Measure life reflects a blend of replace on failure and early replacement. Measure life obtained from GDS Associates, Inc. (2007), Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group; Page 1-3, Table 1. The calculation of blended measure life can be found in MA PAs' 2022-2024 Plan Electric Heating and Cooling Savings Workbook (2021). [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

**7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**8** : NTG results were derived from the following study: [2021 Guidehouse MA Res NTG Final Report](#)

**9** : PA & EEAC assumption value

**10** : [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

## 1.20. HVAC - Combo Condensing Boiler/Water Heater

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-CCBWH                           |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Early Retirement, Retrofit               |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.

### BCR Measure IDs:

| Measure Name                                                                              | Core Initiative                 | BCR Measure ID |
|-------------------------------------------------------------------------------------------|---------------------------------|----------------|
| Combo Condensing Boiler/Water Heater, Other                                               | Residential Retail (RES_RETAIL) | EA2c021        |
| Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other                   | Residential Retail (RES_RETAIL) | EA2c338        |
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95%                             | Residential Retail (RES_RETAIL) | GA2c008        |
| Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | Residential Retail (RES_RETAIL) | GA2c064        |

### Algorithms for Calculating Primary Energy Impact:

Heating System, Combo Condensing Boiler/Water Heater, Gas 95% & Combo Condensing Boiler/Water Heater 95%, Other

Unit savings are deemed based on study results.<sup>1</sup> Savings have been adjusted to reflect the mix of replace and failure and early retirement based on study results.<sup>2</sup> The savings below are the adjusted values.<sup>3</sup>

Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other & Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95%

Unit savings are deemed based on study results. This measure is treated as a retrofit measure with savings being based on going from existing conditions to the high efficiency unit.

| Measure Name                                                                              | ΔMMBtu |
|-------------------------------------------------------------------------------------------|--------|
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95%                             | 11.7   |
| Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other                   | 22.4   |
| Combo Condensing Boiler/Water Heater 95%, Other                                           | 11.7   |
| Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | 22.4   |

### Baseline Efficiency:

Heating System, Combo Condensing Boiler/Water Heater, Gas 95% & Combo Condensing Boiler/Water Heater 95%, Other

The baseline efficiency case is an 86.5% AFUE rated boiler (83.7% AFUE actual) with a 0.604 EF water heater. The ER baseline is an 85% AFUE rated boiler (77.4% AFUE actual) with either an indirect water heater or with a 0.58 EF water heater. 24% were indirect and 76% were storage water heaters.<sup>4</sup>

### High Efficiency:

The high efficiency case is an 95% AFUE condensing boiler (actual was 89.4%) and a 0.95 EF water heater (actual was 89.4%).<sup>8</sup>

### Measure Life:

The measure life is 20 years.<sup>5</sup> for non-moderate income which is due to a blending of savings between early retirement and end of life. For moderate income, the full life of the measure is used which is 23 years.<sup>6</sup>

| Measure Name                                                                              | Core Initiative | PA        | EUL | OYF | RUL | AML |
|-------------------------------------------------------------------------------------------|-----------------|-----------|-----|-----|-----|-----|
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95%                             | RES_RETAIL      | Statewide | 23  | n/a | 7   | 20  |
| Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | RES_RETAIL      | Statewide | 23  | n/a | n/a | 23  |
| Combo Condensing Boiler/Water Heater 95%, Other                                           | RES_RETAIL      | Statewide | 23  | n/a | 7   | 20  |
| Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other                   | RES_RETAIL      | Statewide | 23  | n/a | n/a | 23  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                                              | Core Initiative | PA        | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------------------------------------------------------|-----------------|-----------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95%                             | RES_RETAIL      | Statewide | 1.00 | 1.00            | n/a              | n/a              | n/a              | n/a              | n/a              |
| Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | RES_RETAIL      | Statewide | 1.00 | 1.00            | n/a              | n/a              | n/a              | n/a              | n/a              |
| Combo Condensing Boiler/Water Heater 95%, Other                                           | RES_RETAIL      | Statewide | 1.00 | 1.00            | n/a              | n/a              | n/a              | n/a              | n/a              |
| Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other                   | RES_RETAIL      | Statewide | 1.00 | 1.00            | n/a              | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net to Gross Factors <sup>6</sup>

| Measure Name                                                                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95%                             | RES_RETAIL      | All | 0.36 | .13             | 0.00             | 0.76 |
| Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Combo Condensing Boiler/Water Heater 95%, Other                                           | RES_RETAIL      | All | 0.33 | .13             | 0.00             | 0.80 |
| Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other                   | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

## Non-Energy Impacts:

NEIs are calculated.<sup>7</sup>

| Measure Name                                                                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95%                             | RES_RETAIL      | All | \$75.52            |                      |                   |                     |                     |                       |
| Moderate Income Qualified - Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | RES_RETAIL      | All | \$170.01           |                      |                   |                     |                     |                       |
| Combo Condensing Boiler/Water Heater 95%, Other                                           | RES_RETAIL      | All | \$75.52            |                      |                   |                     |                     |                       |
| Moderate Income Qualified - Combo Condensing Boiler/Water Heater, Other                   | RES_RETAIL      | All | \$170.01           |                      |                   |                     |                     |                       |

## Endnotes:

**1** : The Cadmus Group (2015). High Efficiency Heating Equipment Impact Evaluation

[CADMUS 2014 HEHE Impact Evaluation](#)

**2** : The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing [CADMUS 2013 HEHE Cool](#)

[Smart NTG Evaluation Report](#)

**3** : Savings for gas calculations can be found in the following calculator, propane is set equal to gas -

[MA PAs 2022-2024 Annual Plan Gas HVAC WH Calculations GH 2021-08-20](#)

**4** : The rated efficiency and actual efficiency for the heating portion can be found in the following study, also included in this study is the % of indirect and storage water heaters - [2021 Guidehouse TRM Final Report](#)

**5** : The methodology used to calculate the blended measure life for gas can be found in the following calculator, Propane is assumed to have the same measure life. [MA PAs 2022-2024 Annual](#)

[Plan Gas HVAC WH Calculations GH 2021-08-20](#)

**6** : The measure life is assumed to be the same as for a gas boiler: [2021 Guidehouse TRM Final Report](#)

**6** : For the non-moderate income measures, NTG can be verified with this evaluation study Guidehouse (2021).

For moderate income, the NTG was negotiated between the EEAC and PAs.

[2021 Guidehouse Res NTG Final Results Memo](#)

**7** : NEI source and calculation methodology can be found in the following calculator - [MA PAs 2022-2024 Annual Plan Gas HVAC WH Calculations GH 2021-08-20](#)

**8** : For details on the adjustment factor from rated to actual efficiency, please refer to the following study:

[CADMUS 2014 HEHE Impact Evaluation](#)

## 1.21. HVAC - Combo Furnace/Water Heater

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-CFWH                            |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Lost Opportunity, Retrofit               |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of a combination furnace.

### BCR Measure IDs:

| Measure Name                                                                           | Core Initiative                 | BCR Measure ID |
|----------------------------------------------------------------------------------------|---------------------------------|----------------|
| Combo Condensing Furnace/Water Heater, Other                                           | Residential Retail (RES_RETAIL) | EA2c282        |
| Moderate Income Qualified - Combo Condensing Furnace/Water Heater, Other               | Residential Retail (RES_RETAIL) | EA2c339        |
| Heating System, Combo Condensing Furnace/Water Heater, Gas                             | Residential Retail (RES_RETAIL) | GA2c045        |
| Moderate Income Qualified - Heating System, Combo Condensing Furnace/Water Heater, Gas | Residential Retail (RES_RETAIL) | GA2c065        |

### Algorithms for Calculating Primary Energy Impact:

The heating load for furnaces is 584 therms. This is based on an evaluation of heating equipment installed through the HEHE program and assumed to be representative of single family homes.<sup>1</sup>

$$\Delta \text{ Therms} = \text{heating load} * (1/\text{AFUE}_{\text{base}} - 1/\text{AFUE}_{\text{ee}}) = 584 * (1/0.85 - 1/0.97) = 85 \text{ therms.}$$

The water heating load is 139 therms.<sup>2</sup>

$$\Delta \text{ Therms} = \text{water heating load} * (1/\text{UEF}_{\text{base}} - 1/\text{UEF}_{\text{ee}}) = 139 * (1/0.63 - 1/0.90) = 66 \text{ therms.}$$

For moderate income, there is not blending of savings and we are calculating savings based on existing conditions.

| Measure Name                                                                           | $\Delta$ MMBtu/Unit |
|----------------------------------------------------------------------------------------|---------------------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas                             | 15.1                |
| Combo Condensing Furnace/Water Heater, Other                                           | 15.1                |
| Moderate Income Qualified - Heating System, Combo Condensing Furnace/Water Heater, Gas | 23.7                |
| Moderate Income Qualified - Combo Condensing Furnace/Water Heater, Other               | 23.7                |

**Baseline Efficiency:**

It is assumed that the baseline is an 85% AFUE furnace<sup>3</sup> and a separate high draw gas fired storage water heater with an efficiency rating of 0.63 UEF.

**High Efficiency:**

A new combination 97% AFUE furnace and 0.90 tankless water heater.

**Measure Life:**

The measure life is 17 years.<sup>4</sup>

| Measure Name                                                                           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Heating System, Combo Condensing Furnace/Water Heater, Gas 97%                         | RES_RETAIL      | All | 17  | n/a | n/a | 17  |
| Combo Condensing Furnace/Water Heater, Other                                           | RES_RETAIL      | All | 17  | n/a | n/a | 17  |
| Moderate Income Qualified - Heating System, Combo Condensing Furnace/Water Heater, Gas | RES_RETAIL      | All | 17  | n/a | n/a | 17  |
| Moderate Income Qualified - Combo Condensing Furnace/Water Heater, Other               | RES_RETAIL      | All | 17  | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas 97%                         | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Combo Condensing Furnace/Water Heater, Other                                           | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Moderate Income Qualified - Heating System, Combo Condensing Furnace/Water Heater, Gas | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Moderate Income Qualified - Combo Condensing Furnace/Water Heater, Other               | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates**

All installations have 100% in-service rates since programs include verification of equipment installations.



**Realization Rates**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Impact Factors for Calculating Net Savings <sup>5</sup>

| Measure Name                                                                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas 97%                         | RES_RETAIL      | All | 0.36 | 0.13            | 0.00             | 0.76 |
| Combo Condensing Furnace/Water Heater, Other                                           | RES_RETAIL      | All | 0.33 | 0.13            | 0.00             | 0.80 |
| Moderate Income Qualified - Heating System, Combo Condensing Furnace/Water Heater, Gas | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Moderate Income Qualified - Combo Condensing Furnace/Water Heater, Other               | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

Non-Energy Impacts are calculated. NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                                                           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas 97%                         | RES_RETAIL      | All | \$30.84            | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Combo Condensing Furnace/Water Heater, Other                                           | RES_RETAIL      | All | \$30.84            | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Moderate Income Qualified - Heating System, Combo Condensing Furnace/Water Heater, Gas | RES_RETAIL      | All | \$170.01           | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Moderate Income Qualified - Combo Condensing Furnace/Water Heater, Other               | RES_RETAIL      | All | \$170.01           | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |

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**Endnotes:**

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**1** : The Cadmus Group (2015). High Efficiency Heating Equipment Impact Evaluation.

[CADMUS 2014 HEHE Impact Evaluation](#)

**2** : Navigant Consulting (2018). Water Heater, Boiler, and Furnace Cost Study

[2018 Navigant Water Heater Analysis Memo](#)

**3** : Negotiated value.

**4** : The measure life is set equal to the measure life for a natural gas furnace:

[2021 Guidehouse TRM Final Report](#)

**5** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures

Workbook for the non-moderate income measures. For moderate income measures, the PAs and EEAC negotiated

a 100% NTG value. [2021 Guidehouse MA Res NTG Final Report](#)

## 1.22. HVAC - Communicating Thermostat

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-WT                              |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

A communicating thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems

### BCR Measure IDs:

| Measure Name                                   | Core Initiative                           | BCR Measure ID |
|------------------------------------------------|-------------------------------------------|----------------|
| Wi-Fi Thermostat, Electric (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a290        |
| Wi-Fi Thermostat, AC Only (Single Family)      | Residential Coordinated Delivery (RES_CD) | EA2a064        |
| Wi-Fi Thermostat, Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a065        |
| Wi-Fi Thermostat, Oil (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a067        |
| Wi-Fi Thermostat, Other (Single Family)        | Residential Coordinated Delivery (RES_CD) | EA2a069        |
| Wi-Fi Thermostat, Electric (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a289        |
| Wi-Fi Thermostat, AC Only (Attached Low Rise)  | Residential Coordinated Delivery (RES_CD) | EA2a268        |
| Wi-Fi Thermostat, Gas (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a148        |
| Wi-Fi Thermostat, Oil (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a269        |
| Wi-Fi Thermostat, Other (Attached Low Rise)    | Residential Coordinated Delivery (RES_CD) | EA2a149        |
| Wi-Fi Thermostat, AC Only (High Rise)          | Residential Coordinated Delivery (RES_CD) | EA2a235        |
| Wi-Fi Thermostat, Oil (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a236        |
| Wi-Fi Thermostat, Other (High Rise)            | Residential Coordinated Delivery (RES_CD) | EA2a237        |
| Wi-Fi Thermostat, Electric                     | Residential Retail (RES_RETAIL)           | EA2c275        |
| Wi-Fi Thermostat, AC Only                      | Residential Retail (RES_RETAIL)           | EA2c058        |
| Wi-Fi Thermostat, Gas                          | Residential Retail (RES_RETAIL)           | EA2c060        |

|                                                      |                                           |         |
|------------------------------------------------------|-------------------------------------------|---------|
| Wi-Fi Thermostat, Oil                                | Residential Retail (RES_RETAIL)           | EA2c062 |
| Wi-Fi Thermostat, Other                              | Residential Retail (RES_RETAIL)           | EA2c064 |
| Wi-Fi Thermostat, Gas, gas heat only (Single Family) | Residential Coordinated Delivery (RES_CD) | GA2a013 |
| Wi-Fi Thermostat, Gas (Attached Low Rise)            | Residential Coordinated Delivery (RES_CD) | GA2a058 |
| Wi-Fi Thermostat, Gas (High Rise)                    | Residential Coordinated Delivery (RES_CD) | GA2a092 |
| Wi-Fi Thermostat, Gas                                | Residential Retail (RES_RETAIL)           | GA2c030 |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results. The evaluated electric savings of 64 kWh were adjusted for homes with fossil fuel heat to reflect the percent of homes that have cooling. That proportion is 28 percent, based on the Residential Baseline study.

| Measure Name                                   | Core Initiative | $\Delta\text{kWh}^1$ | $\Delta\text{kW}^2$ | $\Delta\text{MMBtu}^3$ |
|------------------------------------------------|-----------------|----------------------|---------------------|------------------------|
| Wi-Fi Thermostat, Electric (Single Family)     | RES_CD          | 64                   | 0.05                |                        |
| Wi-Fi Thermostat, AC Only (Single Family)      | RES_CD          | 64                   | 0.09                |                        |
| Wi-Fi Thermostat, Gas (Single Family)          | RES_CD          | 18                   | 0.03                | 2.79                   |
| Wi-Fi Thermostat, Oil (Single Family)          | RES_CD          | 18                   | 0.03                | 2.78                   |
| Wi-Fi Thermostat, Other (Single Family)        | RES_CD          | 18                   | 0.03                | 2.78                   |
| Wi-Fi Thermostat, Electric (Attached Low Rise) | RES_CD          | 64                   | 0.05                |                        |
| Wi-Fi Thermostat, AC Only (Attached Low Rise)  | RES_CD          | 64                   | 0.09                |                        |
| Wi-Fi Thermostat, Gas (Attached Low Rise)      | RES_CD          | 18                   | 0.03                | 2.79                   |
| Wi-Fi Thermostat, Oil (Attached Low Rise)      | RES_CD          | 18                   | 0.03                | 2.78                   |
| Wi-Fi Thermostat, Other (Attached Low Rise)    | RES_CD          | 18                   | 0.03                | 2.78                   |
| Wi-Fi Thermostat, AC Only (High Rise)          | RES_CD          | 64                   | 0.09                |                        |
| Wi-Fi Thermostat, Oil (High Rise)              | RES_CD          | 18                   | 0.03                | 2.78                   |
| Wi-Fi Thermostat, Other (High Rise)            | RES_CD          | 18                   | 0.03                | 2.78                   |
| Wi-Fi Thermostat, Gas (High Rise)              | RES_CD          | 18                   | 0.03                | 2.79                   |
| Wi-Fi Thermostat, Electric                     | RES_RETAIL      | 64                   | 0.05                |                        |
| Wi-Fi Thermostat, AC Only                      | RES_RETAIL      | 64                   | 0.09                |                        |
| Wi-Fi Thermostat, Gas                          | RES_RETAIL      | 18                   | 0.03                | 2.79                   |

|                                     |            |             |             |             |
|-------------------------------------|------------|-------------|-------------|-------------|
| Wi-Fi Thermostat, Oil               | RES_RETAIL | 18          | 0.03        | 2.78        |
| Wi-Fi Thermostat, Other             | RES_RETAIL | 18          | 0.03        | 2.78        |
| Wi-Fi Thermostat (instant rebate)** | RES_RETAIL | PA-specific | PA-specific | PA-specific |

\*\*Note: Savings for instant rebate Wi-Fi thermostats (for which the fuel is unknown) are weighted for each PA, based on the evaluated savings of retail thermostats and that PAs proportion of rebated thermostats of each fuel type in that PAs Residential Retail program.

**Baseline Efficiency:**

The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.

**High Efficiency:**

The high efficiency case is an HVAC system that has a Wi-Fi thermostat installed.

**Measure Life:**

The measure life is 15 years.<sup>4</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Wi-Fi Thermostat | RES_CD          | All | 15  | n/a | n/a | 15  |
| Wi-Fi Thermostat | RES_RETAIL      | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Wi-Fi Thermostat, Electric (Single Family) | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.34             | 0.20             |
| Wi-Fi Thermostat, AC Only (Single Family)  | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Wi-Fi Thermostat, Gas (Single Family)      | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Wi-Fi Thermostat, Oil (Single Family)      | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Wi-Fi Thermostat, Other (Single Family)    | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |

|                                                |            |     |      |      |      |      |      |      |      |
|------------------------------------------------|------------|-----|------|------|------|------|------|------|------|
| Wi-Fi Thermostat, Electric (Attached Low Rise) | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.34 | 0.20 |
| Wi-Fi Thermostat, AC Only (Attached Low Rise)  | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Gas (Attached Low Rise)      | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Oil (Attached Low Rise)      | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Other (Attached Low Rise)    | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, AC Only (High Rise)          | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Oil (High Rise)              | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Other (High Rise)            | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Gas (High Rise)              | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Electric                     | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.34 | 0.20 |
| Wi-Fi Thermostat, AC Only                      | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Gas                          | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Oil                          | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat, Other                        | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |
| Wi-Fi Thermostat (instant rebate)              | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 0.00 |

### **In-Service Rates:**

For RCD Single Family and Attached Low Rise in-services rate is blended based on evaluation results.<sup>5 6</sup> For Retail and High Rise all PAs assume 100% in service rate.

### **Realization Rates:**

Realization rates are set to 100% for deemed measures.

### **Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

## Impact Factors for Calculating Net Savings:

Net to gross factors for attached low rise and high rise are based on evaluation results.<sup>8</sup>

| Measure Name                                                    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Wi-Fi Thermostat (Single Family) – electric, oil, and other     | RES_CD          | All | 0.13 | 0.12            | 0                | 0.99 |
| Wi-Fi Thermostat (Single Family) – gas                          | RES_CD          | All | 0.25 | 0.12            | 0                | 0.87 |
| Wi-Fi Thermostat (Attached Low Rise) – electric, oil, and other | RES_CD          | All | 0.13 | 0.12            | 0                | 0.99 |
| Wi-Fi Thermostat (Attached Low Rise) - gas                      | RES_CD          | All | 0.25 | 0.12            | 0                | 0.87 |
| Wi-Fi Thermostat (High Rise) – electric, oil and other          | RES_CD          | All | 0.14 | 0               | 0                | 0.86 |
| Wi-Fi Thermostat (High Rise) - gas                              | RES_CD          | All | 0.14 | 0               | 0                | 0.86 |
| Wi-Fi Thermostat – electric, oil, and other                     | RES_RETAIL      | All | 0.13 | 0.12            | 0                | 0.99 |
| Wi-Fi Thermostat – gas                                          | RES_RETAIL      | All | 0.25 | 0.12            | 0                | 0.87 |

## Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B. The thermostat NEI values are per household and the PAs adjust the total value by the average number of thermostats per account depending on the initiative.

| Measure Name                         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Wi-Fi Thermostat (Single Family)     | RES_CD          | All | \$5.45             |                      |                   |                     |                     |                       |
| Wi-Fi Thermostat (Attached Low Rise) | RES_CD          | All | \$5.45             |                      |                   |                     |                     |                       |
| Wi-Fi Thermostat (High Rise)         | RES_CD          | All | \$14.35            |                      |                   |                     |                     |                       |
| Wi-Fi Thermostat                     | RES_RETAIL      | All | \$5.45             |                      |                   |                     |                     |                       |

## Endnotes:

1 : Navigant Consulting (2018). Wi-Fi Thermostat Impact Evaluation--Secondary Research Study Memo.

[2018 Navigant Wi-Fi Thermostat Impact Evaluation Secondary Literature Study](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

3 : Guidehouse Inc (2021) Residential Wifi and Programmable Thermostat Impacts Report

[2021 Guidehouse Thermostat Impact Study](#)

4 : Assumed to have the same lifetime as a regular programmable thermostat. Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat.

[EPA 2010 Lifecycle Cost Estimate for ENERGY STAR Programmable Thermostats](#)

**5** : Guidehouse (2021). Virtual Home Energy Assessment Study. [2021 Guidehouse VHEA Report FINAL](#)

**6** : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)

**7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**8** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)



### 1.23. HVAC - Down Size 1/2 Ton

|              |                                          |
|--------------|------------------------------------------|
| Measure Code | RES-HVAC-DSHT                            |
| Market       | Residential                              |
| Program Type | Time of Sale                             |
| Category     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Reduction in system size consistent with manual J calculations.

#### BCR Measure IDs:

| Measure Name      | Core Initiative                 | BCR Measure ID |
|-------------------|---------------------------------|----------------|
| Down Size 1/2 Ton | Residential Retail (RES_RETAIL) | EA2c006        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results of DOE2 modeling where a unit is equal to a completed job:<sup>1</sup>

Units = Completed job

$\Delta kWh/Ton$  = Average annual energy reduction per ton

$\Delta kW/Ton$  = Average demand reduction per ton

#### Savings for Down Size 1/2 Ton:

| Measure Name      | Energy Type | $\Delta kWh$ | $\Delta kW$ |
|-------------------|-------------|--------------|-------------|
| Down Size 1/2 Ton | Electric    | 203          | 0.29        |

#### Baseline Efficiency:

The baseline efficiency case is a system that is not sized in accordance with manual J calculation.

#### High Efficiency:

The high efficiency case is a system that is sized in accordance with manual J calculation.

#### Measure Life:

The measure life is based on evaluation results.<sup>2</sup>

| Measure Name      | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------|-----------------|-----|-----|-----|-----|-----|
| Down Size 1/2 Ton | RES_RETAIL      | All | 18  | N/A | N/A | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Down Size 1/2 Ton | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |

**In-Service Rates:**

All installations have 100% in-service rates.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Down Size 1/2 Ton <sup>4</sup> | RES_RETAIL      | All | 0.34 | 0.12            | 0.10             | 0.88 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Down Size 1/2 Ton | RES_RETAIL      | All | \$0.64             |                      |                   |                     |                     |                       |

**Endnotes:**

**1** : RLW Analytics (2002). Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market. Prepared for National Grid, Northeast Utilities, NSTAR, Fitchburg Gas and Electric Light Company and United Illuminating; Page 3, Table 2

[RLW 2002 Market Research for RI MA CT Residential HVAC Market](#)

**2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**4** : NTG values were derived from the following study: [2021 Guidehouse MA Res NTG Final Report](#)

## 1.24. HVAC - Duct Insulation

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-DI                              |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

For existing ductwork in non-conditioned spaces, insulate ductwork.

### BCR Measure IDs:

| Measure Name                               | Core Initiative                           | BCR Measure ID |
|--------------------------------------------|-------------------------------------------|----------------|
| Duct Insulation, Electric (Single Family)  | Residential Coordinated Delivery (RES_CD) | EA2a036        |
| Duct Insulation, Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | EA2a037        |
| Duct Insulation, Oil (Single Family)       | Residential Coordinated Delivery (RES_CD) | EA2a038        |
| Duct Insulation, Other (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a039        |
| Duct Insulation, Elec (Attached Low Rise)  | Residential Coordinated Delivery (RES_CD) | EA2a117        |
| Duct Insulation, Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a118        |
| Duct Insulation, Oil (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a119        |
| Duct Insulation, Other (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a120        |
| Duct Insulation, Elec (High Rise)          | Residential Coordinated Delivery (RES_CD) | EA2a205        |
| Duct Insulation, Gas (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a206        |
| Duct Insulation, Oil (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a207        |
| Duct Insulation, Other (High Rise)         | Residential Coordinated Delivery (RES_CD) | EA2a208        |
| Duct Insulation, Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | GA2a003        |
| Duct Insulation, Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | GA2a048        |
| Duct Insulation, Gas (High Rise)           | Residential Coordinated Delivery (RES_CD) | GA2a082        |

### Algorithms for Calculating Primary Energy Impact:

#### Single Family and Attached Low Rise:

Unit savings are deemed based on study results<sup>1</sup>:

| Measure Name                               | $\Delta kWh$ | $\Delta kW^2$ | $\Delta MMBtu$ |
|--------------------------------------------|--------------|---------------|----------------|
| Duct Insulation, Electric (Single Family)  | 726          | 0.51          |                |
| Duct Insulation, Gas (Single Family)       |              |               | 7.3            |
| Duct Insulation, Oil (Single Family)       |              |               | 7.4            |
| Duct Insulation, Other (Single Family)     |              |               | 7.3            |
| Duct Insulation, Elec (Attached Low Rise)  | 726          | 0.51          |                |
| Duct Insulation, Gas (Attached Low Rise)   |              |               | 7.3            |
| Duct Insulation, Oil (Attached Low Rise)   |              |               | 7.4            |
| Duct Insulation, Other (Attached Low Rise) |              |               | 7.3            |
| Duct Insulation, Gas (Single Family)       |              |               | 7.3            |
| Duct Insulation, Gas (Attached Low Rise)   |              |               | 7.3            |

**High Rise:**

Unit savings are deemed based on study results:

$$\Delta MMBtu = MMBtu \times Units$$

Where:

Unit = Number of square feet of ductwork treated

MMBtu = Average annual MMBtu savings per unit:  $0.035^3$

**Baseline Efficiency:**

The baseline efficiency case is existing, un-insulated ductwork in unconditioned spaces (e.g. attic or basement).

**High Efficiency:**

The high efficiency condition is insulated ductwork in unconditioned spaces.

**Measure Life:**

The measure life is 20 years.<sup>4</sup>

| PA  | Measure Name    | Core Initiative | EUL | OYF | RUL | AML |
|-----|-----------------|-----------------|-----|-----|-----|-----|
| All | Duct Insulation | RES_CD          | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Insulation (Single Family)     | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Duct Insulation (Attached Low Rise) | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Duct Insulation (High Rise)         | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.24             | 0.25             |

#### **In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

#### **Realization Rates:**

For single family and attached low rise realization rates are set to 100% since savings are deemed. For high rise realization rates are based on evaluation results.<sup>5</sup>

#### **Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

### Impact Factors for Calculating Net Savings:

Net-to-gross factors are from evaluation results.<sup>7</sup>

| Measure Name                        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Insulation (Single Family)     | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Duct Insulation (Attached Low Rise) | RES_CD          | All | 0.04 | 0.12            | 0.0              | 1.08 |
| Duct Insulation (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |

#### **Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

#### **Endnotes:**

1 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.

[2018 Navigant HES Impact Evaluation](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

3 : National Grid Staff Estimate (2010) MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)

4 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

6 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

7 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.  
[2021 Guidehouse MA Res NTG Final Report](#)

## 1.25. HVAC - Duct Sealing

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-DSAF                            |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

For existing ductwork in non-conditioned spaces, seal ductwork. This could include sealing leaky fixed ductwork with mastic or aerosol.

### BCR Measure IDs:

| Measure Name                            | Core Initiative                           | BCR Measure ID |
|-----------------------------------------|-------------------------------------------|----------------|
| Duct Sealing, Electric (Single Family)  | Residential Coordinated Delivery (RES_CD) | EA2a040        |
| Duct Sealing, Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | EA2a041        |
| Duct Sealing, Oil (Single Family)       | Residential Coordinated Delivery (RES_CD) | EA2a042        |
| Duct Sealing, Other (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a043        |
| Duct Sealing, Elec (Attached Low Rise)  | Residential Coordinated Delivery (RES_CD) | EA2a113        |
| Duct Sealing, Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a114        |
| Duct Sealing, Oil (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a115        |
| Duct Sealing, Other (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a116        |
| Duct Sealing, Elec (High Rise)          | Residential Coordinated Delivery (RES_CD) | EA2a201        |
| Duct Sealing, Gas (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a202        |
| Duct Sealing, Oil (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a203        |
| Duct Sealing, Other (High Rise)         | Residential Coordinated Delivery (RES_CD) | EA2a204        |
| Duct Sealing, Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | GA2a004        |
| Duct Sealing, Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | GA2a049        |
| Duct Sealing, Gas (High Rise)           | Residential Coordinated Delivery (RES_CD) | GA2a083        |

## Algorithms for Calculating Primary Energy Impact:

### Single Family:

Unit savings are deemed based on study results.<sup>1 2</sup>

| Measure Name                           | $\Delta kWh$ | $\Delta kW^3$ | $\Delta MMBtu$ |
|----------------------------------------|--------------|---------------|----------------|
| Duct Sealing, Electric (Single Family) | 442          | 0.31          |                |
| Duct Sealing, Gas (Single Family)      |              |               | 3.9            |
| Duct Sealing, Oil (Single Family)      |              |               | 4.0            |
| Duct Sealing, Other (Single Family)    |              |               | 3.9            |

### Attached Low Rise and High Rise:

Savings (MMBtu) = Consumption x % SAVE x 1/1,000,000

Where:

Consumption = The total annual heating consumption for the facility (Btu)

%SAVE = Average reduction in energy consumption.

1/1,000,000 = Conversion from Btu to MMBtu.

Savings Factors for Multifamily Duct Sealing:

| Measure Type                          | %SAVE <sup>4</sup> |
|---------------------------------------|--------------------|
| Surface Area < 50 SQFT                | 7%                 |
| Surface Area > 50 SQFT and < 200 SQFT | 3%                 |
| Surface Area > 200 SQFT               | 1%                 |

### **Baseline Efficiency:**

The baseline efficiency case is existing, non-sealed (leaky) ductwork in unconditioned spaces (e.g. attic or basement).

For duct sealing (retail), the baseline efficiency case assumes 15% leakage.

### **High Efficiency:**

The high efficiency condition is air sealed ductwork in unconditioned spaces.

For duct sealing (retail), the high efficiency case is a system with duct leakage reduced by 66% to 5% leakage.



**Measure Life:**

The measure life is 20 years.<sup>5</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Duct Sealing | RES_CD          | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Sealing, Electric (Single Family)  | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Duct Sealing, Gas (Single Family)       | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Oil (Single Family)       | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Other (Single Family)     | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Elec (Attached Low Rise)  | RES_CD          | All | 1.00 | 0.86            | 1.00             | 0.86             | 0.86             | 0.24             | 0.25             |
| Duct Sealing, Gas (Attached Low Rise)   | RES_CD          | All | 1.00 | 1.00            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Oil (Attached Low Rise)   | RES_CD          | All | 1.00 | 1.00            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Other (Attached Low Rise) | RES_CD          | All | 1.00 | 1.00            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Elec (High Rise)          | RES_CD          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.24             | 0.25             |
| Duct Sealing, Gas (High Rise)           | RES_CD          | All | 1.00 | 1.00            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Oil (High Rise)           | RES_CD          | All | 1.00 | 1.00            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Other (High Rise)         | RES_CD          | All | 1.00 | 1.00            | 0.86             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

For single family realization rates are set to 100% since deemed savings are based on evaluated results. For attached low rise and high rise realization rates are based on evaluation results.<sup>6</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

## Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.<sup>8</sup>

| Measure Name                     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Sealing (Single Family)     | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Duct Sealing (Attached Low Rise) | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Duct Sealing (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |

## Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Sealing | RES_CD          | All | \$0.23             |                      |                   |                     |                     |                       |

## Endnotes:

**1** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.

[2018 Navigant HES Impact Evaluation](#)

**2** : Duct sealing (retail) savings based on results of DOE2 modeling as reported in RLW Analytics (2002), Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market, Page 3, Table 2.

[RLW 2002 Market Research for RI MA CT Residential HVAC Market](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**4** : Savings assumptions from National Grid program vendor

**5** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**6** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

**7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**8** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.26. HVAC - Ductless Mini-Split Heat Pump (DMSHP) Quality Installation Verification (QIV)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-MSHPQIV                         |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

The verification of proper charge and airflow during installation of new Ductless Mini-Split Heat Pump (DMSHP) systems.

### BCR Measure IDs:

| Measure Name | Core Initiative                 | BCR Measure ID |
|--------------|---------------------------------|----------------|
| DMSHP QIV    | Residential Retail (RES_RETAIL) | EA2c106        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:<sup>1</sup>

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat} = [\text{Tons} \times 12\text{kBtu/hr/Ton} \times (1/\text{SEER}) \times \text{HOURS}_C \times 5\%] + [\text{Tons} \times 12\text{kBtu/hr/Ton} \times (1/\text{HSPF}) \times \text{HOURS}_H \times 5\%]$$

$$\Delta kW_{cool} = \Delta kWh_{cool} \times \text{Annual Maximum Demand Factor (cool)}$$

$$\Delta kW_{heat} = \Delta kWh_{heat} \times \text{Annual Maximum Demand Factor (heat)}$$

$$\Delta kW = \max(\Delta kW_{cool}, \Delta kW_{heat})$$

Where:

Unit = Completed QIV of new DMSHP system

Tons = Capacity of DMSHP equipment

SEER = Seasonal Energy Efficiency Ratio of DMSHP equipment

HSPF = Heating Seasonal Performance Factor of DMSHP equipment

Hours<sub>C</sub> = Equivalent Full Load Hours (EFLH) for cooling

Hours<sub>H</sub> = EFLH for heating

5% = Average demand reduction of 5%<sup>2</sup>

### Savings for Mini Split Heat Pump QIV:

| Measure Name | Energy Type | Average Capacity (tons) <sup>3</sup> | Average SEER <sup>4</sup> | Average HSPF <sup>5</sup> | Cooling Hours <sup>6</sup><br>Heating Hours <sup>7</sup> | ΔkWh | Annual Max Demand Factor           | ΔkW  |
|--------------|-------------|--------------------------------------|---------------------------|---------------------------|----------------------------------------------------------|------|------------------------------------|------|
| DMSHP QIV    | Electric    | 2.3                                  | 19.7                      | 11.2                      | 218 (cool)<br>535 (heat)                                 | 82.3 | 0.001660 (cool)<br>0.000438 (heat) | 0.10 |

**Baseline Efficiency:**

The baseline efficiency case is a new MSHP system (2.3-ton, SEER 19.7, and HSPF 11.2), based on the quantity-weighted average capacity and efficiency levels of units rebated in the previous calendar year, whose installation is inconsistent with manufacturer specifications.

**High Efficiency:**

The high efficiency case is the same MSHP system whose installation is consistent with manufacturer specifications.

**Measure Life:**

The measure life is based on evaluation results.<sup>8</sup>

| Measure Name | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|--------------|----------------------|-----|-----|-----|-----|-----|
| DMSHP QIV    | RES_CD<br>RES_RETAIL | All | 18  | N/A | N/A | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| DMSHP QIV    | RES_CD<br>RES_RETAIL | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.39             | 0.14             |

**In-Service Rates:**

All quality installation verifications are completed and documented and therefore have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>9</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name | Core Initiative      | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG    |
|--------------|----------------------|-----|------|-----------------|------------------|--------|
| DMSHP QIV    | RES_CD<br>RES_RETAIL | All | 0.0% | 0.0%            | 0.0%             | 100.0% |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name | Core Initiative    | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|--------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| DMSHP QIV    | RES_CD, RES_RETAIL | All | \$1.53             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1** : The calculation of the unit savings can be found in MA PAs' 2022-2024 Plan Annual Report Electric Heating and Cooling Savings Workbook (2021). [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)
- 2** : Average capacity (tons) of heat pump units (weighted by the quantity of heat pump units in each rebate tier) rebated in the full calendar year preceding the year in which this eTRM is published.
- 3** : Average SEER of heat pump units (weighted by the quantity of heat pump units in each rebate tier) rebated in the full calendar year preceding the year in which this eTRM is published.
- 4** : Average HSPF of heat pump units (weighted by the quantity of heat pump units in each rebate tier) rebated in the full calendar year preceding the year in which this eTRM is published.
- 5** : Cooling hours from Cadmus Group (2016). Ductless Mini-Split Heat Pump Impact Evaluation [Cadmus 2016 DMSHP Impact Evaluation](#)
- 6** : Cooling hours from Cadmus Group (2016). Ductless Mini-Split Heat Pump Impact Evaluation [Cadmus 2016 DMSHP Impact Evaluation](#)
- 7** : Heating hours from Navigant Consulting (2018), Quick Hit Study: Ductless Mini-Split Heat Pump Survey (RES 29), March 30, 2018. Assumes higher heating hours for displacement of electric heat based on top 25% EFLH (heating) reported in Cadmus Group (2016), Ductless Mini-Split Heat Pump Impact Evaluation [Navigant 2018 DMSHP Survey](#)
- 8** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 9** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.27. HVAC - Ductless Mini-Split Heat Pump (DMSHP), No Integrated Controls

|                     |                                            |
|---------------------|--------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-DMHP                              |
| <b>Market</b>       | Residential                                |
| <b>Program Type</b> | Replace on Burnout, Retrofit, Time of Sale |
| <b>Category</b>     | Heating Ventilation and Air Conditioning   |

### Measure Description:

The installation of a more efficient ductless mini-split heat pump (DMSHP) system.

### BCR Measure IDs:

| Measure Name                   | Core Initiative                 | BCR Measure ID |
|--------------------------------|---------------------------------|----------------|
| DMSHP, No Integrated Controls  | Residential Retail (RES_RETAIL) | EA2c004        |
| DMSHP Displacing Electric Heat | RES_RETAIL                      | CVE01          |

### Algorithms for Calculating Primary Energy Impact:

Except for high rise applications, DMSHP unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh/ton = \Delta kWh_{cool} + \Delta kWh_{heat} = [12kBtu/hr/Ton \times (1/SEER_{BASE} - 1/SEER_{EE}) \times HOURS_C] + [12kBtu/hr/Ton \times (1/HSPF_{BASE} - 1/HSPF_{EE}) \times HOURS_H]$$

$$\Delta kW = \max(\Delta kW_{cool}, \Delta kW_{heat})$$

$$\Delta kW_{cool} = \Delta kWh_{cool} \times \text{Annual Maximum Demand Factor (cool)}$$

$$\Delta kW_{heat} = \Delta kWh_{heat} \times \text{Annual Maximum Demand Factor (heat)}$$

Where:

Unit = Savings per ton

Tons = Capacity of DMSHP equipment

SEER<sub>BASE</sub> = Seasonal Energy Efficiency Ratio of baseline DMSHP equipment

SEER<sub>EE</sub> = Seasonal Energy Efficiency Ratio of new efficient DMSHP equipment.

HSPF<sub>BASE</sub> = Heating Seasonal Performance Factor of baseline DMSHP equipment

HSPF<sub>EE</sub> = Heating Seasonal Performance Factor of new efficient DMSHP equipment.

Hours<sub>C</sub> = Equivalent Full Load Hours (EFLH) for cooling

Hours<sub>H</sub> = EFLH for heating

Unit savings are counted as the efficiency savings for the high efficiency DMSHP system compared to a code-compliant DMSHP system for the full life of the new high efficiency DMSHP system.

Unit savings for high rise applications are vendor-calculated using technical data and inputs specific to the high rise building or housing units in which the DMSHPs are being installed.

**Savings for Residential Ductless Mini-Split Heat Pumps <sup>1</sup>**

| Measure Name                  | Energy Type | Average Capacity (tons) | Average SEER | Average HSPF | Cooling Hours<br>Heating Hours | ΔkWh  | Annual Max Demand Factor <sup>8</sup> | ΔkW  |
|-------------------------------|-------------|-------------------------|--------------|--------------|--------------------------------|-------|---------------------------------------|------|
| DMSHP, No Integrated Controls | Electric    | 2.33                    | 19.7         | 11.2         | 218 (cool)<br>535 (heat)       | 584.2 | 0.00117                               | 0.68 |

**Baseline Efficiency:**

The baseline is an industry standard 2.33-ton, SEER 15.0, HSPF 8.2 DMSHP system.

**High Efficiency:**

The minimum program qualifications for the high efficiency case is a 16 SEER 9.5 DMSHP system. For savings the high efficiency is based on the average capacity and efficiency levels of systems rebated in the previous calendar year which is 19.7 SEER and 11.2 HSPF.

**Measure Life:**

The measure life is based on evaluation results.<sup>2</sup>

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| DMSHP, No Integrated Controls | RES_RETAIL      | All | 18  | n/a | n/a | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| DMSHP, No Integrated Controls | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.38             | 0.05             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>4</sup>

| Measure Name                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------|
| DDMSHP, No Integrated Controls | RES_RETAIL      | All | 0.34 | 0.12            | 0.00             | 0.88 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| DMSHP, No Integrated Controls | RES_RETAIL      | All | \$4.21             | \$0.00               | \$0.00            | \$0.00              | N/A                 | N/A                   |

**Endnotes:**

1 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

2 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

4: NTG values were derived from the following study: [2021 Guidehouse Res NTG Final Results Memo](#)



## 1.28. HVAC - ECM Circulator Pump

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-ECMCP                           |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of high efficiency residential boiler circulator pumps, including electronically commutated variable speed air supply motors.

### BCR Measure IDs:

| Measure Name    | Core Initiative                 | BCR Measure ID |
|-----------------|---------------------------------|----------------|
| Circulator Pump | Residential Retail (RES_RETAIL) | EA2c009        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results.<sup>1</sup>

| Measure Name    | $\Delta kWh$ | $\Delta kW$ |
|-----------------|--------------|-------------|
| Circulator Pump | 75.2         | 0.05        |

### Baseline Efficiency:

The baseline efficiency case is the installation of a standard circulator pump.

### High Efficiency:

The high efficiency case is the installation of an ECM circulator pump.

### Measure Life:

The measure life is based on evaluation results.<sup>2</sup>

| Measure Name    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|-----|
| Circulator Pump | RES_RETAIL      | All | 20  | N/A | N/A | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Circulator Pump | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are based on evaluation results.

**Impact Factors for Calculating Net Savings:**

| Measure Name                 | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Circulator Pump <sup>3</sup> | RES_RETAIL      | All | 34.0% | 12.0%           | 10.0%            | 88.0% |

**Non-Energy Impacts:**

There are no non-energy impacts for this measure.

**Endnotes:**

**1** : Savings were derived from the ECM Circulator Study: [2021 Guidehouse ECM Circulator](#)

**2** : Assumed to be consistent with C&I Electric Motors & Drives – Energy & Resources Solutions (2005).

Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1. [ERS 2005 Measure Life Study](#)

**3** : [2021 Guidehouse MA Res NTG Final Report](#)

## 1.29. HVAC - Forced Hot Water Boiler, Propane

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-BFW                             |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of a new high efficiency boiler for space heating.

### BCR Measure IDs:

| Core Initiative                                                | Measure Name                    | BCR Measure ID |
|----------------------------------------------------------------|---------------------------------|----------------|
| Heating System, Boiler, Propane (non-condensing to condensing) | Residential Retail (RES_RETAIL) | EA2c012        |
| Moderate Income Qualified - Heating System, Boiler, Propane    | Residential Retail (RES_RETAIL) | EA2c334        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated based on deemed inputs.

$MMBtu = \text{heating load MMBTUs} * (1/AFUE_{base} - 1/AFUE_{ee})$

Where:

Heating load = 96.51 MMBTUs

Energy Savings for Primary Impact<sup>1</sup>

| Measure Name                                                   | $\Delta MMBtu$ |
|----------------------------------------------------------------|----------------|
| Heating System, Boiler, Propane (non-condensing to condensing) | 12.1           |
| Moderate Income Qualified - Heating System, Boiler, Propane    | 16.5           |

### Baseline Efficiency:

Heating System, Boiler, Propane (non-condensing to condensing)

For propane the baseline is an industry standard practice (ISP) non-condensing boiler (AFUE = 83.16% ) adjusted by a degradation factor (0.967) to account for its metered efficiency (AFUE=80.42%).

Moderate Income Qualified - Heating System, Boiler, Propane

For propane the baseline is an existing non-condensing boiler (AFUE = 80% ) adjusted by a degradation factor (0.967) to account for its metered efficiency (AFUE=77%).

**High Efficiency:**

For the 95 AFUE qualifying propane unit the high efficiency case AFUE 95% adjusted by a degradation factor (0.941) to account for its metered efficiency (AFUE=89.4%).

**Measure Life:**

| Measure Name                                                                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Heating System, Boiler, Propane (non-condensing to condensing) <sup>2</sup> | RES_RETAIL      | All | 23  | n/a | n/a | 23  |
| Moderate Income Qualified - Heating System, Boiler, Propane                 | RES_RETAIL      | All | 23  | n/a | n/a | 23  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                   | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System, Boiler, Propane (non-condensing to condensing) | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Moderate Income Qualified - Heating System, Boiler, Propane    | RES_RETAIL      | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based study results.

| Measure Name                                                                | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heating System, Boiler, Propane (non-condensing to condensing) <sup>3</sup> | RES_RETAIL      | All | 0.33 | 0.13            | 0.00             | 0.80 |

|                                                                          |            |     |      |      |      |      |
|--------------------------------------------------------------------------|------------|-----|------|------|------|------|
| Moderate Income Qualified - Heating System, Boiler, Propane <sup>4</sup> | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
|--------------------------------------------------------------------------|------------|-----|------|------|------|------|

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>5</sup>

| Measure Name                                                   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System, Boiler, Propane (non-condensing to condensing) | RES_RETAIL      | All | \$30.84            |                      |                   |                     |                     |                       |
| Moderate Income Qualified - Heating System, Boiler, Propane    | RES_RETAIL      | All | \$170.01           |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : Oil/Propane Savings Calculator [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)
- 2 : ML set equal to gas measure life using the following source: [2021 Guidehouse TRM Final Report](#)
- 3 : NTG study results can be found here: [2021 Guidehouse Res NTG Final Results Memo](#)
- 4 : An agreed upon assumption between the PAs and EEAC.
- 5 : MA PAs (2021). 2022-2024 Oil and Propane HVAC Calculations Workbook [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)

### 1.30. HVAC - Furnace, Oil/Propane

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-FOP                             |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Lost Opportunity, Retrofit               |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a new high efficiency space heating furnace. Electric savings can be attributed to reduced fan run time.

#### BCR Measure IDs:

| Measure Name                                                    | Core Initiative                 | BCR Measure ID |
|-----------------------------------------------------------------|---------------------------------|----------------|
| Heating System, Furnace, Oil                                    | Residential Retail (RES_RETAIL) | EA2c013        |
| Heating System, Furnace, Propane (non-condensing to condensing) | Residential Retail (RES_RETAIL) | EA2c014        |
| Moderate Income Qualified - Heating System, Furnace, Oil        | Residential Retail (RES_RETAIL) | EA2c336        |
| Moderate Income Qualified - Heating System, Furnace, Other      | Residential Retail (RES_RETAIL) | EA2c337        |

#### Algorithms for Calculating Primary Energy Impact:

Heating System, Furnace, Other

Unit savings are calculated based on deemed inputs.

$$\text{MMBtu} = \text{heating load MMBTUs} * (1/\text{AFUE base} - 1/\text{AFUEee})$$

Where:

$$\text{Heating load Propane} = 58.35^1$$

Energy Savings for Primary Energy Impact <sup>2</sup>

Moderate Income Qualified - Heating System, Furnace, Oil

$$\text{MMBtu} = \text{heating load MMBTUs} * (1/\text{AFUE base} - 1/\text{AFUEee})$$

$$\text{Heating load Oil} = 68.41 \text{ MMBTUs}$$

Moderate Income Qualified - Heating System, Furnace, Other

$$\text{MMBtu} = \text{heating load MMBTUs} * (1/\text{AFUE base} - 1/\text{AFUEee})$$

$$\text{Heating load Propane} = 58.35^1$$

| Measure Name                                                    | $\Delta$ MMBtu | $\Delta$ kWh | $\Delta$ kW |
|-----------------------------------------------------------------|----------------|--------------|-------------|
| Heating System, Furnace, Oil                                    | 4.7            | N/A          | N/A         |
| Heating System, Furnace, Propane (non-condensing to condensing) | 12.1           | N/A          | N/A         |
| Moderate Income Qualified - Heating System, Furnace, Oil        | 8.2            | 0            | 0           |
| Moderate Income Qualified - Heating System, Furnace, Other      | 15.7           | 0            | 0           |

### Baseline Efficiency:

#### Heating System, Furnace, Other

The baseline efficiency case is an 80% AFUE rated non-condensing efficiency adjusted to a 80.96% AFUE actual efficiency propane furnace.<sup>4</sup> There is not early retirement savings being claimed for the propane furnace.

#### Moderate Income Qualified - Heating System, Furnace, Oil

The baseline efficiency case is an existing 77% AFUE rated furnace adjusted to a 78.0% AFUE actual efficiency propane furnace.

#### Moderate Income Qualified - Heating System, Furnace, Other

The baseline efficiency case is an existing 75% AFUE rated furnace adjusted to a 75.7% AFUE actual efficiency propane furnace.

### High Efficiency:

The high efficiency case is a new 86% AFUE oil furnace or a 95% AFUE propane furnace.

### Measure Life:

This measure has a blend of early retirement savings and end of life savings.<sup>5</sup>

| Measure Name                                                    | Core Initiative | PA  | EUL <sup>6</sup> | OYF | RUL | AML |
|-----------------------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Heating System, Furnace, Oil                                    | RES_RETAIL      | All | 17               | n/a | n/a | 12  |
| Heating System, Furnace, Propane (non-condensing to condensing) | RES_RETAIL      | All | 17               | n/a | n/a | 17  |
| Moderate Income Qualified - Heating System, Furnace, Oil        | RES_RETAIL      | All | 17               | n/a | n/a | 17  |
| Moderate Income Qualified - Heating System, Furnace, Other      | RES_RETAIL      | All | 17               | n/a | n/a | 17  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System, Furnace, Propane (non-condensing to condensing) | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| Moderate Income Qualified - Heating System, Furnace, Oil        | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| Moderate Income Qualified - Heating System, Furnace, Other      | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

N/A

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>7</sup>

| Measure Name                                                    | Core Initiative | PA  | FR    | SOP   | SONP | NTG    |
|-----------------------------------------------------------------|-----------------|-----|-------|-------|------|--------|
| Heating System, Furnace, Propane (non-condensing to condensing) | RES_RETAIL      | All | 32.5% | 12.7% | 0%   | 80.2%  |
| Moderate Income Qualified - Heating System, Furnace, Oil        | RES_RETAIL      | All | 0.0%  | 0.0%  | 0.0% | 100.0% |
| Moderate Income Qualified - Heating System, Furnace, Other      | RES_RETAIL      | All | 0.0%  | 0.0%  | 0.0% | 100.0% |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>8</sup>

| Measure Name                                                    | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System, Furnace, Propane (non-condensing to condensing) | RES_RETAIL      | All | \$30.84            |                      |                   |                     |                     |                       |
| Moderate Income Qualified - Heating System, Furnace, Oil        | RES_RETAIL      | All | \$170.01           |                      |                   |                     |                     |                       |



|                                                            |            |     |          |  |  |  |  |  |
|------------------------------------------------------------|------------|-----|----------|--|--|--|--|--|
| Moderate Income Qualified - Heating System, Furnace, Other | RES_RETAIL | All | \$170.01 |  |  |  |  |  |
|------------------------------------------------------------|------------|-----|----------|--|--|--|--|--|

**Endnotes:**

- 1** : MA PAs (2021). 2022-2024 Annual Plan Oil and Propane HVAC Calculations Workbook. [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)
- 2** : Calculations can be found in the MA PAs (2021). 2022-2024 Plan Oil and Propane HVAC Calculations Workbook. [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)
- 3** : MA PAs (2021). 2022-2024 Annual Plan Oil and Propane HVAC Calculations Workbook. [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)
- 4** : Industry Standard Practice [2021 Guidehouse TRM Final Report](#)
- 6** : For more information on the blended savings, please refer to this workbook: [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)
- 5** : The ML is set equal to that of an gas furnace using the following source: [2021 Guidehouse TRM Final Report](#)
- 7** : NTG values can be found in the following summary file: [2021 Guidehouse MA Res NTG Final Report](#)
- 8** : MA PAs (2021). 2022-2024 Annual Plan Oil and Propane HVAC Calculations Workbook. [MA PAs 2022-2024 Annual Report Oil Propane HVAC Calculations 2021-08-20](#)

### 1.31. HVAC - Furnace/Boiler, Gas

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-FG                              |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

**Measure Description:**

Installation of a new high efficiency space heating furnace with an electronically commutated motor (ECM) for the fan.

**BCR Measure IDs:**

| Measure Name                                                              | Core Initiative                 | BCR Measure ID |
|---------------------------------------------------------------------------|---------------------------------|----------------|
| Furnace, Non-Condensing to Condensing 95 AFUE                             | Residential Retail (RES_RETAIL) | GA2c036        |
| Furnace, Non-Condensing to Condensing 97 AFUE                             | Residential Retail (RES_RETAIL) | GA2c037        |
| Boiler, Non-Condensing to Condensing 95 AFUE                              | Residential Retail (RES_RETAIL) | GA2c038        |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 95 AFUE | Residential Retail (RES_RETAIL) | GA2c066        |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 97 AFUE | Residential Retail (RES_RETAIL) | GA2c067        |
| Moderate Income Qualified - Boiler, Non-Condensing to Condensing 95 AFUE  | Residential Retail (RES_RETAIL) | GA2c068        |

**Algorithms for Calculating Primary Energy Impact:**

For all non-moderate income measures, unit savings are calculated based on deemed inputs and assumed the program has verified that the existing unit was a non-condensing furnace. <sup>1</sup>

For all moderate income measures, unit savings is set equal to the savings for the single family income eligible equivalent measure. For moderate income furnaces, there is also ECM furnace savings.

| Measure Name                                                              | $\Delta$ MMBtu | $\Delta$ kWh | Max Demand Factor | $\Delta$ kW |
|---------------------------------------------------------------------------|----------------|--------------|-------------------|-------------|
| Furnace, Non-Condensing to Condensing 95 AFUE                             | 10.8           | N/A          | N/A               | N/A         |
| Furnace, Non-Condensing to Condensing 97 AFUE                             | 12.0           | N/A          | N/A               | N/A         |
| Boiler, Non-Condensing to Condensing 95 AFUE                              | 12.1           | N/A          | N/A               | N/A         |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 95 AFUE | 20.7           | 172          | 0.00073           | 0.13        |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 97 AFUE | 20.7           | 172          | 0.00073           | 0.13        |
| Moderate Income Qualified - Boiler, Non-Condensing to Condensing 95 AFUE  | 19.4           | N/A          | N/A               | N/A         |

### Baseline Efficiency:

For all non-moderate income measures the furnace the baseline efficiency case is an 80% AFUE non-condensing furnace adjusted to 81% AFUE actual efficiency. For the boiler the baseline efficiency case is an 83.2% AFUE non-condensing boiler adjusted to 80.4% AFUE actual efficiency,<sup>2</sup>

For all moderate income measures, the baseline is equal to an existing furnace or boiler

### High Efficiency:

The high efficiency case is either a new furnace with AFUE  $\geq$  95% (actual 95.2% AFUE) with an electronically commutated motor installed or AFUE  $\geq$  97% (Actual 97.2% AFUE) with an electronically commutated motor installed. for the boiler measures, the high efficiency case is a new 95% or greater AFUE boiler.

### Measure Life:

The measure life is 17 years for the furnace and 23 years for the boiler.<sup>3</sup>

| Measure Name                                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Furnace, Non-Condensing to Condensing 95 AFUE | RES_RETAIL      | All | 17  | n/a | n/a | 17  |
| Furnace, Non-Condensing to Condensing 97 AFUE | RES_RETAIL      | All | 17  | n/a | n/a | 17  |
| Boiler, Non-Condensing to Condensing 95 AFUE  | RES_RETAIL      | All | 23  | n/a | n/a | 23  |

|                                                                                 |            |     |    |     |     |    |
|---------------------------------------------------------------------------------|------------|-----|----|-----|-----|----|
| Moderate Income Qualified -<br>Furnace, Non-Condensing to<br>Condensing 95 AFUE | RES_RETAIL | All | 17 | n/a | n/a | 17 |
| Moderate Income Qualified -<br>Furnace, Non-Condensing to<br>Condensing 97 AFUE | RES_RETAIL | All | 17 | n/a | n/a | 17 |
| Moderate Income Qualified -<br>Boiler, Non-Condensing to<br>Condensing 95 AFUE  | RES_RETAIL | All | 23 | n/a | n/a | 23 |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                                                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Furnace, Non-Condensing to<br>Condensing 95 AFUE                                | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| Furnace, Non-Condensing to<br>Condensing 97 AFUE                                | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| Boiler, Non-Condensing to<br>Condensing 95 AFUE                                 | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |
| Moderate Income Qualified -<br>Furnace, Non-Condensing to<br>Condensing 95 AFUE | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |
| Moderate Income Qualified -<br>Furnace, Non-Condensing to<br>Condensing 97 AFUE | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |
| Moderate Income Qualified -<br>Boiler, Non-Condensing to<br>Condensing 95 AFUE  | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.00             |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

All PAs use 100% energy realization rate.

**Coincidence Factors:**

N/A

**Impact Factors for Calculating Net Savings:**Net to gross factors are based on evaluation results.<sup>4</sup>

| Measure Name                                                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Furnace, Non-Condensing to Condensing 95 AFUE                             | RES_RETAIL      | All | 0.36 | 0.13            | 0.00             | 0.76 |
| Furnace, Non-Condensing to Condensing 97 AFUE                             | RES_RETAIL      | All | 0.36 | 0.13            | 0.00             | 0.76 |
| Boiler, Non-Condensing to Condensing 95 AFUE                              | RES_RETAIL      | All | 0.36 | 0.13            | 0.00             | 0.76 |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 95 AFUE | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 97 AFUE | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Moderate Income Qualified - Boiler, Non-Condensing to Condensing 95 AFUE  | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**NEI values are rolled up, component values can be found in Appendix B.<sup>5</sup>

| Measure Name                                                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Furnace, Non-Condensing to Condensing 95 AFUE                             | RES_RETAIL      | All | \$30.84            |                      |                   |                     |                     |                       |
| Furnace, Non-Condensing to Condensing 97 AFUE                             | RES_RETAIL      | All | \$30.84            |                      |                   |                     |                     |                       |
| Boiler, Non-Condensing to Condensing 95 AFUE                              | RES_RETAIL      | All | \$30.84            |                      |                   |                     |                     |                       |
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 95 AFUE | RES_RETAIL      | All | \$170.01           |                      |                   |                     |                     |                       |

|                                                                           |            |     |          |  |  |  |  |  |
|---------------------------------------------------------------------------|------------|-----|----------|--|--|--|--|--|
| Moderate Income Qualified - Furnace, Non-Condensing to Condensing 97 AFUE | RES_RETAIL | All | \$170.01 |  |  |  |  |  |
| Moderate Income Qualified - Boiler, Non-Condensing to Condensing 95 AFUE  | RES_RETAIL | All | \$170.01 |  |  |  |  |  |

**Endnotes:**

**1** : The calculation of the adjustment can be found in MA PAs (2021). 2020 Annual Report Gas HVAC and Water Heating Calculations Workbook. [MA PAs 2022-2024 Annual Plan Gas HVAC WH Calculations GH 2021-08-20](#)

**2** : For more information both on the baseline and the adjustment from rated efficiency to actual efficiency, please refer to the following spreadsheet: [MA PAs 2022-2024 Annual Plan Gas HVAC WH Calculations GH 2021-08-20](#)

**3** : Lifetime values for all measures were derived from the following study: [2021 Guidehouse TRM Final Report](#)

**4** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)

**5** : The calculation of the adjustment can be found in MA PAs (2021). 2022-2024 Annual Plan Gas HVAC and Water Heating Calculations Workbook. [MA PAs 2022-2024 Annual Plan Gas HVAC WH Calculations GH 2021-08-20](#)

### 1.32. HVAC - Heat Pump - Custom

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-HP-C                            |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a heat pump displacing electric, oil, or propane heat.

#### BCR Measure IDs:

| Measure Name                                 | Core Initiative                           | BCR Measure ID |
|----------------------------------------------|-------------------------------------------|----------------|
| Custom - Heat Pumps displacing Electric Heat | Residential Coordinated Delivery (RES_CD) | EA2a248        |
| Custom - Heat Pumps displacing Oil           | Residential Coordinated Delivery (RES_CD) | EA2a276        |
| Custom - Heat Pumps displacing Propane       | Residential Coordinated Delivery (RES_CD) | EA2a277        |
| CVEO Heat Pumps, Electric Heat               | Residential Coordinated Delivery (RES_CD) | CVEO1          |
| CVEO Heat Pumps, Oil                         | Residential Coordinated Delivery (RES_CD) | CVEO2          |
| CVEO Heat Pumps, Propane                     | Residential Coordinated Delivery (RES_CD) | CVEO3          |

#### Algorithms for Calculating Primary Energy Impact:

For custom, heat pump savings will be calculated by the vendor based on existing site conditions.

For CVEO, heat pump savings will be calculated using the same assumptions and methods as the measures shown in the following table. In addition, all assumptions for these measures will be based on the BCR Measure Data Source.

| Measure Name                   | Core Initiative                           | BCR Measure ID | PA  | BCR Measure Data Source |
|--------------------------------|-------------------------------------------|----------------|-----|-------------------------|
| CVEO Heat Pumps, Electric Heat | Residential Coordinated Delivery (RES_CD) | CVEO1          | CLC | EA2C315                 |

|                          |                                           |       |     |                                                                                      |
|--------------------------|-------------------------------------------|-------|-----|--------------------------------------------------------------------------------------|
| CVEO Heat Pumps, Oil     | Residential Coordinated Delivery (RES_CD) | CVEO2 | CLC | EA2c270<br>EA2C268<br>EA2c273<br>EA2c290<br>EA2c317<br>EA2c323<br>EA2c325<br>EA2c327 |
| CVEO Heat Pumps, Propane | Residential Coordinated Delivery (RES_CD) | CVEO3 | CLC | EA2c269<br>EA2c267<br>EA2c274<br>EA2c291<br>EA2c318<br>EA2c324<br>EA2c326<br>EA2c328 |

**Baseline Efficiency:**

For custom, the baseline efficiency case is the existing site conditions.

**High Efficiency:**

For custom, the high efficiency case will vary by site.

**Measure Life:**

The measure life will vary depending on the type of equipment installed.

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.



**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Custom Heat Pumps, Displacing Electric Heat (High Rise) | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |
| Custom Heat Pumps, Displacing Oil (High Rise)           | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.34             | 0.17             |
| Custom Heat Pumps, Displacing Propane (High Rise)       | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.34             | 0.17             |

**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% because the measure is new and has not been evaluated.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>1</sup>

**Impact Factors for Calculating Net Savings:**

NTG rates are based on an evaluation study.<sup>2</sup>

| Measure Name                                            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Custom Heat Pumps, Displacing Electric Heat (High Rise) | RES_CD          | All | 0.14 | 0.00            | 0.00             | 0.86 |
| Custom Heat Pumps, Displacing Oil (High Rise)           | RES_CD          | All | 0.14 | 0.00            | 0.00             | 0.86 |
| Custom Heat Pumps, Displacing Propane (High Rise)       | RES_CD          | All | 0.14 | 0.00            | 0.00             | 0.86 |

**Non-Energy Impacts:**

NEIs are rolled up. Component values can be found in Appendix B.<sup>3</sup>

| Measure Name | Core Initiative | PA | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
|--------------|-----------------|----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|

|                                                               |        |     |        |  |  |  |  |  |
|---------------------------------------------------------------|--------|-----|--------|--|--|--|--|--|
| Custom Heat Pumps,<br>Displacing Electric Heat (High<br>Rise) | RES_CD | All | \$5.98 |  |  |  |  |  |
| Custom Heat Pumps,<br>Displacing Oil (High Rise)              | RES_CD | All | \$5.98 |  |  |  |  |  |
| Custom Heat Pumps,<br>Displacing Propane (High<br>Rise)       | RES_CD | All | \$5.98 |  |  |  |  |  |

**Endnotes:**

1 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

2 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)

3 : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.

[Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

### 1.33. HVAC - Heat Pump Digital Check-up/Tune-up

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-HPDCU                           |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Operations and Maintenance               |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Tune-up of an existing air source central heat pump system.

#### BCR Measure IDs:

| Measure Name                       | Core Initiative                 | BCR Measure ID |
|------------------------------------|---------------------------------|----------------|
| Heat Pump Digital Check-up/Tune-Up | Residential Retail (RES_RETAIL) | EA2c007        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:<sup>1</sup>

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat} = [Tons \times 12kWh/hr/Ton \times (1/SEER) \times HOURS_C \times 5\%] + [Tons \times 12kWh/hr/Ton \times (1/HSPF) \times HOURS_H \times 5\%]$$

$$\Delta kW_{cool} = \Delta kWh_{cool} \times \text{Annual Maximum Demand Factor (cool)}$$

$$\Delta kW_{heat} = \Delta kWh_{heat} \times \text{Annual Maximum Demand Factor (heat)}$$

$$\Delta kW = \max(\Delta kW_{cool}, \Delta kW_{heat})$$

#### Where:

Unit = Completed tune-up of existing heat pump system

Tons = Capacity of existing HP equipment

SEER = Seasonal Energy Efficiency Ratio of existing HP equipment

HSPF = Heating Seasonal Performance Factor of existing HP equipment

Hours<sub>C</sub> = Equivalent Full Load Hours (EFLH) for cooling

Hours<sub>H</sub> = EFLH for heating

5% = Average demand reduction of 5%<sup>2</sup>

#### Savings for Heat Pump Digital Check-up/Tune-Up:

| Measure Name                       | Energy Type | Average Capacity (tons) <sup>3</sup> | SEER | HSPF | Hours <sup>4</sup>         | ΔkWh | Annual Max Demand Factor <sup>5</sup> | ΔkW  |
|------------------------------------|-------------|--------------------------------------|------|------|----------------------------|------|---------------------------------------|------|
| Heat Pump Digital Check-Up/Tune-Up | Electric    | 3.03                                 | 13.0 | 7.7  | 419 (cool)<br>1,200 (heat) | 342  | 0.00117                               | 0.40 |

**Baseline Efficiency:**

The baseline efficiency case is an existing, inefficient central heat pump system (SEER 13 and HSPF 7.7) that is not operating according to manufacturer specifications.

**High Efficiency:**

The high efficiency case is the same central heat pump system that is operating according to manufacturer specifications.

**Measure Life:**

The measure life is based on evaluation results.<sup>6</sup>

| Measure Name                       | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Heat Pump Digital Check-Up/Tune-Up | RES_RETAIL      | All | 5   | N/A | N/A | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heat Pump Digital Check-up/Tune-Up | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.38             | 0.05             |

**In-Service Rates:**

All installations have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                       | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Heat Pump Digital Check-up/Tune-Up | RES_RETAIL      | All | 34.0% | 12.0%           | 10.0%            | 88.0% |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heat Pump Digital Check-up/Tune-up | RES_RETAIL      | All | \$1.53             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1** : The calculation of the unit savings can be found in MA PAs' 2022-2024 Electric Heating and Cooling Savings Workbook (2021). [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)
- 2** : Massachusetts Common Assumptions.
- 3** : The Tonnage size is based on the previous years production values.
- 4** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study (cooling hours). [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 6** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

### 1.34. HVAC - Heat Pump Fully Displacing Existing Boiler

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-FS-DMSHP                        |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Full displacement of a boiler with a high efficiency ductless minisplit heat pump for heating.

#### BCR Measure IDs:

| Measure Name                                                                           | Core Initiative                 | BCR Measure ID |
|----------------------------------------------------------------------------------------|---------------------------------|----------------|
| DMSHP displacing Electric Heat                                                         | Residential Retail (RES_RETAIL) | EA2c256        |
| DMSHP Fully Displacing Existing Boiler, Oil                                            | Residential Retail (RES_RETAIL) | EA2c273        |
| DMSHP Fully Displacing Existing Boiler, Propane                                        | Residential Retail (RES_RETAIL) | EA2c274        |
| DMSHP Fully Displacing Existing Boiler, Gas                                            | Residential Retail (RES_RETAIL) | GA2c073        |
| Air-to-Water Heat Pump displacing Existing Boiler, Oil                                 | Residential Retail (RES_RETAIL) | EA2c290        |
| Air-to-Water Heat Pump displacing Existing Boiler, Propane                             | Residential Retail (RES_RETAIL) | EA2c291        |
| Air-to-Water Heat Pump displacing Existing Boiler, Gas                                 | Residential Retail (RES_RETAIL) | GA2c074        |
| Moderate Income Qualified - DMSHP displacing Electric Heat                             | Residential Retail (RES_RETAIL) | EA2c315        |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Oil                | Residential Retail (RES_RETAIL) | EA2c325        |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Propane            | Residential Retail (RES_RETAIL) | EA2c326        |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Oil     | Residential Retail (RES_RETAIL) | EA2c327        |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Propane | Residential Retail (RES_RETAIL) | EA2c328        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings.<sup>1</sup> Savings were calculated via simulation model runs assuming the existing heating system or zones will be fully displaced.<sup>2</sup>

Capacity for DMSHP Replacing Electric Heat = 2.0 Tons

Capacity of new Heat Pump for oil/propane = 3.9 Tons<sup>3</sup>

The same savings are used for moderate income and standard income projects.

| Measure Name                                       | Saved MMBtu<br>Oil/Propane/Gas<br>Per Ton/Per Whole Home | $\Delta$ kW<br>Per Ton/Per Whole<br>Home | $\Delta$ kWh<br>Per Ton/Per Whole<br>Home |
|----------------------------------------------------|----------------------------------------------------------|------------------------------------------|-------------------------------------------|
| DMSHP displacing<br>Electric Heat                  | 3.75/<br>7.49                                            | 2.32/<br>4.64                            | 1670/<br>3340                             |
| DMSHP Fully Displacing<br>Existing Boiler, Oil     | 17.8/<br>69.3                                            | -0.75<br>-2.92                           | -1982/<br>-7730                           |
| DMSHP Fully Displacing<br>Existing Boiler, Propane | 17.8/<br>69.3                                            | -0.75<br>-2.92                           | -1982/<br>-7730                           |
| DMSHP Fully Displacing<br>Existing Boiler, Gas     | 17.8/<br>69.3                                            | -0.75<br>-2.92                           | -1982/<br>-7730                           |

### For Air to Water Heat Pump

Information on the savings analysis can be found here<sup>4 5</sup> This is for all Air-to-water heat pump measures; oil, gas and propane.

| Measure Name                                         | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBTU Fuel Savings |
|------------------------------------------------------|--------------|-------------|-----------------------------|
| Air-to-Water Heat Pump<br>displacing Existing Boiler | -7644.9      | -8.15       | 91.3                        |

### Baseline Efficiency:

For propane the baseline is an existing inefficient boiler at 77.4% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83.7% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention. For oil the baseline is an existing inefficient boiler at 79.4% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 86% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention. For electric resistance, the baseline is a 100% efficient or 3.41 COP.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention. <sup>6</sup>

The baseline for air to water HP is a standard new oil, propane or gas boiler - AFUE 84 %, Baseline for the GSHP is an 83 AFUE oil boiler and an 85 AFUE propane boiler.

### High Efficiency:

DMSHP Fully displacing any fuel

For the minimum program qualifications, the high efficiency case is a new 16 SEER/9.5 HSPF ductless mini split heat pumps. Due to expected program changes, savings will only be claimed going up to a standard heat pump (15 SEER and 8.2 HSPF) for all the listed measures. The remaining savings or going from a code/ISP heat pump to the 16 SEER/9.5 HSPF heat pump will be claimed under the standard heat pump offering (HVAC - Ductless Mini-Split Heat Pump (DMSHP), No Integrated Controls).

Air to Water Heat Pump displacing any fuel

The high efficiency measure is installing a high efficiency air-to-water heat pump with a minimum COP of 1.7 used for heating.

### Measure Life:

The same measure life is used for both moderate income and standard income projects

| Measure Name                               | Core Initiative | PA  | EUL <sup>7</sup> | OYF | RUL | AML |
|--------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| DMSHP Fully displacing any fuel            | RES_RETAIL      | All | 18               | n/a | n/a | 18  |
| Air to Water Heat Pump displacing any fuel | RES_RETAIL      | All | 17               | n/a | n/a | 17  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| DMSHP displacing Electric Heat                  | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.02            | 0.31             |
| DMSHP Fully Displacing Existing Boiler, Oil     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.08             | 0.67             |
| DMSHP Fully Displacing Existing Boiler, Propane | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.08             | 0.67             |
| DMSHP Fully Displacing Existing Boiler, Gas     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.08             | 0.67             |



|                                                                                        |            |     |      |      |      |      |      |      |       |      |
|----------------------------------------------------------------------------------------|------------|-----|------|------|------|------|------|------|-------|------|
| Air-to-Water Heat Pump displacing Existing Boiler, Oil                                 | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |
| Air-to-Water Heat Pump displacing Existing Boiler, Propane                             | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |
| Air-to-Water Heat Pump displacing Existing Boiler, Gas                                 | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |
| Moderate Income Qualified - DMSHP displacing Electric Heat                             | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.31 |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Oil                | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.08  | 0.67 |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Propane            | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.08  | 0.67 |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Gas                | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.08  | 0.67 |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Oil     | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Propane | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Gas     | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |

**In-Service Rates:**

All installations have 100% in-service rates 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 <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>8</sup> |
|----------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| DMSHP displacing Electric Heat                                                         | RES_RETAIL      | All | 0.34 | 0.12            | 0.10             | 0.88             |
| DMSHP Fully Displacing Existing Boiler, Oil                                            | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| DMSHP Fully Displacing Existing Boiler, Propane                                        | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| DMSHP Fully Displacing Existing Boiler, Gas                                            | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| Air-to-Water Heat Pump displacing Existing Boiler, Oil                                 | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| Air-to-Water Heat Pump displacing Existing Boiler, Propane                             | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| Air-to-Water Heat Pump displacing Existing Boiler, Gas                                 | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| Moderate Income Qualified - DMSHP displacing Electric Heat                             | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Oil                | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Propane            | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |
| Moderate Income Qualified - DMSHP Fully Displacing Existing Boiler, Gas                | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Oil     | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Propane | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |
| Moderate Income Qualified - Air-to-Water Heat Pump displacing Existing Boiler, Gas     | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00             |

## Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B. All measures not listed below do not have any current NEI values

| Measure Name                                               | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| DMSHP displacing Electric Heat                             | RES_RETAIL      | All | \$4.21             | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Moderate Income Qualified - DMSHP displacing Electric Heat | RES_RETAIL      | All | \$18.03            | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |

## Endnotes:

- 1 : Savings were derived from energy simulation models that came from: [2021 Guidehouse Fuel Displacement Report HP](#)
- 2 : [2021 Guidehouse Fuel Displacement Report HP](#)
- 3 : Tonnage sizes were calculated based on 2019 production in the residential retail program and can be found in the following evaluation study (will be updated when study is final).
- 4 : Air to Water Source Heat Pump replacing Oil Calculations [2020 New Measure Form - AtoWHP Oil](#)
- 5 : Air to Water Source Heat Pump replacing propane calculations [2020 New Measure Form -AtoWhP Propane](#)
- 6 : More information on both the baseline definitions and weights can be found in the following study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 7 : Measure life Air source heat Pump GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 8 : NTG results were derived from the following study: [2021 Guidehouse MA Res NTG Final Report](#)

### 1.35. HVAC - Heat Pump Fully Displacing Existing Furnace

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-FSHP                            |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Full displacement of an existing inefficient propane or oil furnace with a high efficiency central ducted heat pump.

#### BCR Measure IDs:

| Measure Name                                                                                    | Core Initiative                 | BCR Measure ID |
|-------------------------------------------------------------------------------------------------|---------------------------------|----------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil                                 | Residential Retail (RES_RETAIL) | EA2c272        |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane                             | Residential Retail (RES_RETAIL) | EA2c271        |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Gas                                 | Residential Retail (RES_RETAIL) | GA2c071        |
| Moderate Income Qualified - Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | Residential Retail (RES_RETAIL) | EA2c321        |
| Moderate Income Qualified - Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | Residential Retail (RES_RETAIL) | EA2c322        |
| Closed Loop GSHP Replacing Furnace, Oil                                                         | Residential Retail (RES_RETAIL) | EA2c292        |
| Closed Loop GSHP Replacing Furnace, Propane                                                     | Residential Retail (RES_RETAIL) | EA2c293        |
| Closed Loop GSHP Replacing Furnace, Gas                                                         | Residential Retail (RES_RETAIL) | EA2c075        |
| Open Loop GSHP Replacing Furnace, Oil                                                           | Residential Retail (RES_RETAIL) | EA2c294        |
| Open Loop GSHP Replacing Furnace, Propane                                                       | Residential Retail (RES_RETAIL) | EA2c295        |
| Open Loop GSHP Replacing Furnace, Gas                                                           | Residential Retail (RES_RETAIL) | GA2c076        |
| Moderate Income Qualified - Closed Loop GSHP Replacing Furnace, Oil                             | Residential Retail (RES_RETAIL) | EA2c329        |
| Moderate Income Qualified - Closed Loop GSHP Replacing Furnace, Propane                         | Residential Retail (RES_RETAIL) | EA2c330        |

|                                                                       |                                 |         |
|-----------------------------------------------------------------------|---------------------------------|---------|
| Moderate Income Qualified - Open Loop GSHP Replacing Furnace, Oil     | Residential Retail (RES_RETAIL) | EA2c331 |
| Moderate Income Qualified - Open Loop GSHP Replacing Furnace, Propane | Residential Retail (RES_RETAIL) | EA2c332 |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings.<sup>1</sup> Savings were calculated via simulation model runs assuming the existing heating system will be fully displaced.<sup>2</sup>

Capacity of new Heat Pump = 4.7 Tons<sup>3</sup>

Same savings are used for both standard and moderate income.

| Measure Name                                                        | Saved MMBtu Oil/Propane/Gas Per Ton/Per Whole Home | $\Delta kW$     | $\Delta kWh$     |
|---------------------------------------------------------------------|----------------------------------------------------|-----------------|------------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | 17.9/83.9                                          | -0.87/<br>-4.09 | -2132/<br>-10020 |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | 17.9/83.9                                          | -0.87/<br>-4.09 | -2132/<br>-10020 |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Gas     | 17.9/83.9                                          | -0.87/<br>-4.09 | -2132/<br>-10020 |

### For Ground Source Heat Pump

Information on the savings analysis can be found here<sup>4</sup> Gas savings are set equal to the propane savings.

| Measure Name                                        | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBTU$<br>Fuel Savings |
|-----------------------------------------------------|--------------|-------------|--------------------------------|
| Closed Loop GSHP Replacing Furnace, Oil             | -5721        | -2.5        | 82.4                           |
| Closed Loop GSHP Replacing Furnace, Propane and Gas | -5721        | -2.5        | 80.5                           |
| Open Loop GSHP Replacing Furnace, Oil               | -4844        | -2.2        | 82.4                           |
| Open Loop GSHP Replacing Furnace, Propane and Gas   | -4844        | -2.2        | 80.5                           |

### Baseline Efficiency:

For propane the baseline is an existing inefficient furnace at 81% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 90.1% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention. For oil the baseline is an existing inefficient furnace at 77.7% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention.<sup>5</sup>

Baseline for the GSHP is an 83 AFUE oil boiler and an 85 AFUE propane boiler.

### High Efficiency:

For the minimum program qualifications, the high efficiency case is a new 4.7 ton 16 SEER/9.5 HSPF ducted central heat pump.

The high efficiency for a closed loop GSHP minimum efficiency is a 3.6 COP and 17.1 EER. For an open loop GSHP the minimum efficiency is a 4.1 COP and a 21.1 EER.

### Measure Life:

Same Measure life is sued for all central heat pumps and all ground source heat pumps.

| Measure Name                                               | Core Initiative | PA  | EUL <sup>6</sup> | OYF | RUL | AML |
|------------------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Central Ducted Heat Pump Fully Displacing Existing Furnace | RES_RETAIL      | All | 17               | n/a | n/a | 17  |
| Ground Source Heat Pump                                    | RES_RETAIL      | All | 30               | n/a | n/a | 30  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.02            | 0.65             |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.02            | 0.65             |

|                                                                 |            |     |      |      |      |      |      |       |      |
|-----------------------------------------------------------------|------------|-----|------|------|------|------|------|-------|------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Gas | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.02 | 0.65 |
| Closed Loop GSHP Replacing Furnace                              | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.01 | 0.21 |
| Open Loop GSHP Replacing Furnace                                | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.05 | 0.21 |

**In-Service Rates:**

All installations have 100% in-service rates 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 calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name <sup>7</sup>                                                                       | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil                                 | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane                             | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Gas                                 | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Moderate Income Qualified - Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Moderate Income Qualified - Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Closed Loop GSHP Replacing Furnace, Oil                                                         | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Closed Loop GSHP Replacing Furnace, Propane                                                     | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Closed Loop GSHP Replacing Furnace, Gas                                                         | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Open Loop GSHP Replacing Furnace, Oil                                                           | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Open Loop GSHP Replacing Furnace, Propane                                                       | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Open Loop GSHP Replacing Furnace, Gas                                                           | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91 |
| Moderate Income Qualified - Closed Loop GSHP Replacing Furnace, Oil                             | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

|                                                                         |            |     |      |      |      |      |
|-------------------------------------------------------------------------|------------|-----|------|------|------|------|
| Moderate Income Qualified - Closed Loop GSHP Replacing Furnace, Propane | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Moderate Income Qualified - Open Loop GSHP Replacing Furnace, Oil       | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Moderate Income Qualified - Open Loop GSHP Replacing Furnace, Propane   | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 1 : Savings were derived from energy simulation models that came from: [2021 Guidehouse Fuel Displacement Report HP](#)
- 2 : More information on the savings calculations can be found in the following study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 3 : Tonnage sizes were calculated based on 2019 production in the residential retail program and can be found in the following evaluation study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 4 : Details for the four GSHP offerings can be found in the new measure process form here: [new measure form 4 GSHP Measures-03-05-2021](#)
- 5 : More information on the baseline calculations can be found in the following study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 6 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 7 : NTG results can be found in the following study results. [2021 Guidehouse MA Res NTG Final Report](#)



## 1.36. HVAC - Heat Pump Partially Displacing Existing Boiler

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-FS-DMSHP-P                      |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Partial displacement of a boiler with a high efficiency ductless minisplit heat pump for heating.

### BCR Measure IDs:

| Measure Name                                                                                             | Core Initiative                 | BCR Measure ID |
|----------------------------------------------------------------------------------------------------------|---------------------------------|----------------|
| DMSHP Integrated Controls Retrofit Oil                                                                   | Residential Retail (RES_RETAIL) | EA2c270        |
| DMSHP Integrated Controls Retrofit, Propane                                                              | Residential Retail (RES_RETAIL) | EA2c269        |
| DMSHP Integrated Controls Retrofit, Gas                                                                  | Residential Retail (RES_RETAIL) | GA2c069        |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil                                 | Residential Retail (RES_RETAIL) | EA2c268        |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane                             | Residential Retail (RES_RETAIL) | EA2c267        |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Gas                                 | Residential Retail (RES_RETAIL) | GA2c072        |
| Moderate Income Qualified - DMSHP Integrated Controls Retrofit Oil                                       | Residential Retail (RES_RETAIL) | EA2c317        |
| Moderate Income Qualified - DMSHP Integrated Controls Retrofit, Propane                                  | Residential Retail (RES_RETAIL) | EA2c318        |
| Moderate Income Qualified - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil     | Residential Retail (RES_RETAIL) | EA2c323        |
| Moderate Income Qualified - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | Residential Retail (RES_RETAIL) | EA2c324        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and

include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings. Savings were calculated via simulation model runs assuming using a weighted average of survey responses for the most accurate switch over temperature between the MSHP and the secondary heating source. Due to expected program changes, the weighting were updated for each year of the three year plan showing better control strategies for propane throughout the three year plan. <sup>1 2</sup>

Capacity for DMSHP Replacing Electric Heat = 2.0 Tons

Capacity of Heat Pump for all other measure = 2.8 Tons <sup>3</sup>

Same gross savings will be claimed for both moderate income and standard income measures.

| Year      | Measure Name                                                                       | Saved MMBtu<br>Oil/Propane/Gas<br>Per Ton/ Per Home | ΔkW<br>Per Ton/<br>Per Home | ΔkWh<br>Per Ton/<br>Per Home |
|-----------|------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------|------------------------------|
| 2022-2024 | DMSHP with Integrated Controls<br>Partially Displacing Existing<br>Boiler, Oil     | 16.1/45.0                                           | -0.51/<br>-1.42             | -1505/<br>-4213              |
| 2022      | DMSHP with Integrated Controls<br>Partially Displacing Existing<br>Boiler, Propane | 17.4/48.7                                           | -0.57/<br>-1.61             | -1658/<br>-4642              |
| 2023      | DMSHP with Integrated Controls<br>Partially Displacing Existing<br>Boiler, Propane | 18.3/51.1                                           | -0.61/<br>-1.71             | -1743/<br>-4881              |
| 2024      | DMSHP with Integrated Controls<br>Partially Displacing Existing<br>Boiler, Propane | 19.1/<br>53.6                                       | -.065/<br>-1.81             | -1828/<br>-5119              |
| 2022-2024 | DMSHP with Integrated Controls<br>Partially Displacing Existing<br>Boiler, Gas     | 16.1/45.0                                           | -0.51/<br>-1.42             | -1505/<br>-4213              |
| 2022-2024 | DMSHP Integrated Controls<br>Retrofit Oil                                          | 8.8/<br>24.6                                        | -0.26/<br>-0.71             | -599/<br>-1678               |
| 2022-2024 | DMSHP Integrated Controls<br>Retrofit, Propane                                     | 9.01/<br>25.2                                       | -0.26/<br>-0.71             | -599/<br>-1678               |
| 2022-2024 | DMSHP Integrated Controls<br>Retrofit, Gas                                         | 8.8/<br>24.6                                        | -0.26/<br>-0.71             | -599/<br>-1678               |

### Baseline Efficiency:

For propane the baseline is an existing inefficient boiler at 77.4% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83.7% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention. For oil the baseline is an existing inefficient boiler at 79.4% AFUE when the customer survey responses stated that the existing unit

was functioning properly and a 86% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention. For integrated controls retrofit measure, the baseline is a previously installed heat pump with no integrated controls. <sup>4</sup>

### High Efficiency:

For the minimum program qualifications, the high efficiency case is a new 16 SEER/9.5 HSPF ductless mini split heat pumps. Due to expected program changes, savings will only be claimed going up to a standard heat pump (15 SEER and 8.2 HSPF) for all the listed measures with the exception of the controls only retrofit measures. For the non-controls only measures, the remaining savings or going from a code/ISP heat pump to the 16 SEER/9.5 HSPF heat pump will be claimed under the standard heat pump offering (HVAC - Ductless Mini-Split Heat Pump (DMSHP), No Integrated Controls).

### Measure Life:

| Measure Name                       | Core Initiative | PA  | EUL <sup>5</sup> | OYF | RUL | AML |
|------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| DMSHP with Integrated Controls     | RES_RETAIL      | All | 18               | n/a | n/a | 18  |
| DMSHP Integrated Controls Retrofit | RES_RETAIL      | All | 10               | n/a | n/a | 10  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                                             | Core Initiative | PA  | ISR  | RRE  | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------------------------|-----------------|-----|------|------|------------------|------------------|------------------|------------------|------------------|
| DMSHP Integrated Controls Retrofit Oil                                   | RES_RETAIL      | All | 1.00 | 1.00 | 1.00             | 1.00             | 1.00             | 0.00             | 0.63             |
| DMSHP Integrated Controls Retrofit, Propane                              | RES_RETAIL      | All | 1.00 | 1.00 | 1.00             | 1.00             | 1.00             | 0.00             | 0.63             |
| DMSHP Integrated Controls Retrofit, Gas                                  | RES_RETAIL      | All | 1.00 | 1.00 | 1.00             | 1.00             | 1.00             | 0.16             | 0.73             |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil | RES_RETAIL      | All | 1.00 | 1.00 | 1.00             | 1.00             | 1.00             | 0.16             | 0.73             |

|                                                                                                          |            |     |      |      |      |      |      |      |      |
|----------------------------------------------------------------------------------------------------------|------------|-----|------|------|------|------|------|------|------|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane                             | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.16 | 0.73 |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Gas                                 | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.16 | 0.73 |
| Moderate Income Qualified - DMSHP Integrated Controls Retrofit Oil                                       | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.63 |
| Moderate Income Qualified - DMSHP Integrated Controls Retrofit, Propane                                  | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.63 |
| Moderate Income Qualified - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil     | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.16 | 0.73 |
| Moderate Income Qualified - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.16 | 0.73 |

**In-Service Rates:**

All installations have 100% in-service rates 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:**

Net-to-gross factors are per agreement with the MA EEAC Consultants.

| Measure Name                                | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>6</sup> |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| DMSHP Integrated Controls Retrofit Oil      | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| DMSHP Integrated Controls Retrofit, Propane | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| DMSHP Integrated Controls Retrofit, Gas     | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |

|                                                                                                          |            |     |      |      |      |      |
|----------------------------------------------------------------------------------------------------------|------------|-----|------|------|------|------|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil                                 | RES_RETAIL | All | 0.31 | 0.22 | 0.00 | 0.91 |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane                             | RES_RETAIL | All | 0.31 | 0.22 | 0.00 | 0.91 |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Gas                                 | RES_RETAIL | All | 0.31 | 0.22 | 0.00 | 0.91 |
| Moderate Income Qualified - DMSHP Integrated Controls Retrofit Oil                                       | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Moderate Income Qualified - DMSHP Integrated Controls Retrofit, Propane                                  | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Moderate Income Qualified - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil     | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Moderate Income Qualified - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |

### Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

### Endnotes:

**1** : Savings were derived from energy simulation models that came from the following study:

[2021 Guidehouse Fuel Displacement Report HP](#)

**2** : For more information on the weighting and savings calculations please refer to the evaluation report:

[2021 Guidehouse Fuel Displacement Report HP](#)

**3** : Tonnage sizes were calculated based on 2019 production and can be found in the following evaluation study:

[2021 Guidehouse Fuel Displacement Report HP](#)

**4** : More information on the baseline methodology can be found in the following report: [2021 Guidehouse Fuel Displacement Report HP](#)

**5** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**6** : For moderate income, the NTG is set at 100% and is a negotiated value. For the other measures, the following study used customer surveys to estimate the NTG: [2021 Guidehouse MA Res NTG Final Report](#)

## 1.37. HVAC - Heat Pump Partially Displacing Existing Furnace

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-FSHP-P                          |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Partial displacement of an existing oil or propane furnace with a high efficiency central ducted heat pump.

### BCR Measure IDs:

| Measure Name                                                                                        | Core Initiative                 | BCR Measure ID |
|-----------------------------------------------------------------------------------------------------|---------------------------------|----------------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil                                 | Residential Retail (RES_RETAIL) | EA2c266        |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane                             | Residential Retail (RES_RETAIL) | EA2c265        |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Gas                                 | Residential Retail (RES_RETAIL) | GA2c070        |
| Moderate Income Qualified - Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil     | Residential Retail (RES_RETAIL) | EA2c319        |
| Moderate Income Qualified - Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | Residential Retail (RES_RETAIL) | EA2c320        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings. Energy Savings were calculated via energy simulation models. The crossover temp was modelled at several different crossover temps via customer survey responses and the results were weighted by the distribution of responses. Due to expected program changes, the weighting were updated for each year of the three year plan showing better control strategies for propane throughout the three year plan.<sup>1 2</sup>

Capacity of new Heat Pump = 3.7 tons<sup>3</sup>

Gross savings are the same between the standard and moderate income measure offerings.

| Year      | Measure Name                                                               | Saved MMBtu<br>Oil/Propane/Gas<br>Per Ton/Per<br>Whole Home | $\Delta$ kW<br>Per Ton/Per<br>Whole Home | $\Delta$ kWh<br>Per Ton/Per<br>Whole Home |
|-----------|----------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------|-------------------------------------------|
| 2022-2024 | Central Ducted Heat Pump Partially<br>Displacing Existing Furnace, Oil     | 13.4/49.6                                                   | -0.47/-1.75                              | -1233/-4563                               |
| 2022-2024 | Central Ducted Heat Pump Partially<br>Displacing Existing Furnace, Gas     | 13.4/49.6                                                   | -0.47/-1.75                              | -1233/-4563                               |
| 2022      | Central Ducted Heat Pump Partially<br>Displacing Existing Furnace, Propane | 15.1/56.0                                                   | -0.55/-2.03                              | -1408/-5210                               |
| 2023      | Central Ducted Heat Pump Partially<br>Displacing Existing Furnace, Propane | 17.3/64.1                                                   | -0.67/-2.49                              | -1700/-6290                               |
| 2024      | Central Ducted Heat Pump Partially<br>Displacing Existing Furnace, Propane | 18.2/67.4                                                   | -0.72/-2.67                              | -1817/-6722                               |

### Baseline Efficiency:

For propane the baseline is an existing inefficient furnace at 81% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 90.1% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention. For oil the baseline is an existing inefficient furnace at 77.7% AFUE furnace when the customer survey responses stated that the existing unit was functioning properly and a 83% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention.<sup>4</sup>

### High Efficiency:

For the minimum program qualifications, the high efficiency case is a new 3.7-ton 16 SEER/9.5 HSPF ducted central heat pump. Savings are calculated based on a standard efficiency heat pump (14 SEER and 8.2 HSPF). Savings going from a standard heat pump to a high efficiency heat pump is claimed under the HVAC - Air Source Central Heat Pump measure offering.

### Measure Life:

The measure life is based on evaluation results.<sup>5</sup>

| Measure Name                                                      | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Central Ducted Heat Pump Partially<br>Displacing Existing Furnace | RES_RETAIL      | All | 17  | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                                                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil                                 | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane                             | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Gas                                 | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |
| Moderate Income Qualified - Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |
| Moderate Income Qualified - Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |

**In-Service Rates:**

All installations have 100% in-service rates 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 PA-calculated to reflect the blend of heating and cooling provided by heat pumps.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                                            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>6</sup> |
|-------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil     | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Gas     | RES_RETAIL      | All | 0.31 | 0.22            | 0.00             | 0.91             |



|                                                                                                     |            |     |      |      |      |      |
|-----------------------------------------------------------------------------------------------------|------------|-----|------|------|------|------|
| Moderate Income Qualified - Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil     | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Moderate Income Qualified - Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | RES_RETAIL | All | 0.00 | 0.00 | 0.00 | 1.00 |

### Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

### Endnotes:

**1** : Savings were derived from energy simulation models that came from the following study:

[2021 Guidehouse Fuel Displacement Report HP](#)

**2** : More information on the savings methodology can be found in the report: [2021 Guidehouse Fuel Displacement Report HP](#)

**3** : Tonnage sizes were calculated based on 2019 production via the retail program delivery and can be found in the following evaluation study: [2021 Guidehouse Fuel Displacement Report HP](#)

**4** : More information on the baselines and the weighted methodology can be found in the report:

[2021 Guidehouse Fuel Displacement Report HP](#)

**5** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**6** : For moderate income, the NTG is assumed to be 100%. For the other measures, NTG results came from the following study: [2021 Guidehouse MA Res NTG Final Report](#)

### 1.38. HVAC - Heat Pump Quality Installation Verification (QIV)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-HPQIV                           |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

**Measure Description:**

The verification of proper charge and airflow during installation of new Heat Pump systems.

**BCR Measure IDs:**

|                     |                                 |                       |
|---------------------|---------------------------------|-----------------------|
| <b>Measure Name</b> | <b>Core Initiative</b>          | <b>BCR Measure ID</b> |
| Heat Pump QIV       | Residential Retail (RES_RETAIL) | EA2c105               |

**Algorithms for Calculating Primary Energy Impact:**

Unit savings are deemed based on the following algorithms and assumptions:<sup>1</sup>

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat} = [Tons \times 12kWh/hr/Ton \times (1/SEER) \times HOURS_C \times 5\%] + [Tons \times 12kWh/hr/Ton \times (1/HSPF) \times HOURS_H \times 5\%]$$

$$\Delta kW_{cool} = \Delta kWh_{cool} \times \text{Annual Maximum Demand Factor (cool)}$$

$$\Delta kW_{heat} = \Delta kWh_{heat} \times \text{Annual Maximum Demand Factor (heat)}$$

$$\Delta kW = \max(\Delta kW_{cool}, \Delta kW_{heat})$$

**Where:**

- Unit = Completed QIV of new central heat pump system
- Tons = Capacity of HP equipment
- SEER = Seasonal Energy Efficiency Ratio of HP equipment
- HSPF = Heating Seasonal Performance Factor of HP equipment
- Hours<sub>C</sub> = Equivalent Full Load Hours (EFLH) for cooling
- Hours<sub>H</sub> = EFLH for heating
- 5% = Average demand reduction of 5%<sup>2</sup>

**Savings for Heat Pump QIV:**

| Measure Name  | Energy Type | Average Capacity (tons) <sup>3</sup> | Average SEER <sup>4</sup> | Average HSPF <sup>5</sup> | Hours <sup>6</sup>         | ΔkWh | Annual Max Demand Factor <sup>7</sup> | ΔkW  |
|---------------|-------------|--------------------------------------|---------------------------|---------------------------|----------------------------|------|---------------------------------------|------|
| Heat Pump QIV | Electric    | 3.03                                 | 17.6                      | 9.81                      | 419 (cool)<br>1,200 (heat) | 266  | 0.00117                               | 0.31 |

**Baseline Efficiency:**

The baseline efficiency case is a new central heat pump system (3.03-ton, SEER 17.6, and HSPF 9.81), based on the quantity-weighted average capacity and efficiency levels of units rebated in the previous calendar year, whose installation is inconsistent with manufacturer specifications.

**High Efficiency:**

The high efficiency case is the same heat pump system whose installation is consistent with manufacturer specifications.

**Measure Life:**

The measure life is based on evaluation results.<sup>8</sup>

| Measure Name  | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|---------------|----------------------|-----|-----|-----|-----|-----|
| Heat Pump QIV | RES_CD<br>RES_RETAIL | All | 18  | N/A | N/A | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heat Pump QIV | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.38             | 0.05             |

**In-Service Rates:**

All quality installation verifications are completed and documented and therefore have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>9</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------|-----------------|-----|------|-----------------|------------------|------|
| Heat Pump QIV | RES_RETAIL      | All | 0.34 | 0.12            | 0.10             | 0.88 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heat Pump QIV | RES_RETAIL      | All | \$1.53             | \$0.00               | \$0.00            | \$0.00              | N/A                 | N/A                   |

**Endnotes:**

**1** : The calculation of the unit savings can be found in MA PA's 2022-2024 Plan Electric Heating and Cooling Savings Workbook (2021). [MA PAs 2022-2024 Planning Electric H&C Savings Workbook 2021-06-17](#)

**2** : Massachusetts Common Assumptions.

**3** : Average capacity (tons) of heat pump units (weighted by the quantity of heat pump units in each rebate tier) rebated in the full calendar year preceding the year in which this eTRM is published.

**4** : Average HSPF of heat pump units (weighted by the quantity of heat pump units in each rebate tier) rebated in the full calendar year preceding the year in which this eTRM is published.

**5** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study (cooling hours).

[2018 Navigant Baseline Loadshape Comprehensive Report](#)

**6** : Navigant Consulting (2018). RES 1 Baseline Load Shape Study (cooling hours).

[2018 Navigant Baseline Loadshape Comprehensive Report](#)

**7** : Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study [2020 Guidehouse Residential Baseline Phase 4](#)

**8** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**9** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.39. HVAC - Heat Recovery Ventilator

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-HRV                             |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Heat Recovery Ventilators (HRV) can help make mechanical ventilation more cost effective by reclaiming energy from exhaust airflows.

### BCR Measure IDs:

| Measure Name                                      | Core Initiative                           | BCR Measure ID |
|---------------------------------------------------|-------------------------------------------|----------------|
| Heat Recovery Ventilator, Gas - Midstream         | Residential Retail (RES_RETAIL)           | EA2c279        |
| Heat Recovery Ventilator, Oil - Midstream         | Residential Retail (RES_RETAIL)           | EA2c280        |
| Heat Recovery Ventilator, Other - Midstream       | Residential Retail (RES_RETAIL)           | EA2c281        |
| Heat Recovery Ventilator, Gas (Single Family)     | Residential Coordinated Delivery (RES_CD) | GA2a040        |
| Heat Recovery Ventilator, Gas (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | GA2a074        |
| Heat Recovery Ventilator, Gas                     | Residential Retail (RES_RETAIL)           | GA2c022        |
| Heat Recovery Ventilator, Gas - Midstream         | Residential Retail (RES_RETAIL)           | GA2c049        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results.<sup>1</sup> An electric penalty results due to the electricity consumed by the system fans.

| Measure Name             | $\Delta$ MMBtu/Unit | $\Delta$ kWh/Unit | $\Delta$ kW/Unit |
|--------------------------|---------------------|-------------------|------------------|
| Heat Recovery Ventilator | 8.6                 | -171              | -0.12            |

### Baseline Efficiency:

The baseline efficiency case is an ASHRAE 62.2-compliant exhaust fan system with no heat recovery.

**High Efficiency:**

The high efficiency case is an exhaust fan system with heat recovery.

**Measure Life:**

The measure life is based on evaluation results.<sup>2</sup>

| Measure Name             | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|--------------------------|----------------------|-----|-----|-----|-----|-----|
| Heat Recovery Ventilator | RES_RETAIL<br>RES_CD | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name             | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heat Recovery Ventilator | RES_RETAIL<br>RES_CD | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.22             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                                      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heat Recovery Ventilator, Gas - Midstream         | RES_RETAIL      | All | 0.36 | 0.12            | 0.00             | 0.76 |
| Heat Recovery Ventilator, Oil - Midstream         | RES_RETAIL      | All | 0.33 | 0.12            | 0.01             | 0.80 |
| Heat Recovery Ventilator, Other - Midstream       | RES_RETAIL      | All | 0.33 | 0.12            | 0.01             | 0.80 |
| Heat Recovery Ventilator, Gas (Single Family)     | RES_CD          | All | 0.36 | 0.12            | 0.00             | 0.76 |
| Heat Recovery Ventilator, Gas (Attached Low Rise) | RES_CD          | All | 0.36 | 0.12            | 0.00             | 0.76 |
| Heat Recovery Ventilator, Gas                     | RES_CD          | All | 0.36 | 0.12            | 0.00             | 0.76 |

|                                           |        |     |      |      |      |      |
|-------------------------------------------|--------|-----|------|------|------|------|
| Heat Recovery Ventilator, Gas - Midstream | RES_CD | All | 0.36 | 0.12 | 0.00 | 0.76 |
|-------------------------------------------|--------|-----|------|------|------|------|

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

1 : TRM Study Update [2021 Guidehouse TRM Final Report](#)

2 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts.

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.40. HVAC - Pipe Wrap (Heating)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-PW                              |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Insulation upgrades to existing heating system pipes

### BCR Measure IDs:

| Measure Name                                   | Core Initiative                           | BCR Measure ID |
|------------------------------------------------|-------------------------------------------|----------------|
| Pipe Wrap (Heating), Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | EA2a048        |
| Pipe Wrap (Heating), Oil (Single Family)       | Residential Coordinated Delivery (RES_CD) | EA2a049        |
| Pipe Wrap (Heating), Other (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a050        |
| Pipe Wrap (Heating), Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a125        |
| Pipe Wrap (Heating), Oil (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a126        |
| Pipe Wrap (Heating), Other (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a127        |
| Pipe Wrap (Heating), Gas (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a213        |
| Pipe Wrap (Heating), Oil (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a214        |
| Pipe Wrap (Heating), Other (High Rise)         | Residential Coordinated Delivery (RES_CD) | EA2a215        |
| Pipe Wrap (Heating), Gas (Single Family)       | Residential Coordinated Delivery (RES_CD) | GA2a006        |
| Pipe Wrap (Heating), Gas (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | GA2a051        |
| Pipe Wrap (Heating), Gas (High Rise)           | Residential Coordinated Delivery (RES_CD) | GA2a085        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results where unit is a household for single family with pipe wrap installed on heating pipes and per linear foot for attached low rise and high rise.<sup>1</sup>

| Measure Name                             | $\Delta$ MMBtu |
|------------------------------------------|----------------|
| Pipe Wrap (Heating), Gas (Single Family) | 1.4            |



|                                                |      |
|------------------------------------------------|------|
| Pipe Wrap (Heating), Oil (Single Family)       | 1.5  |
| Pipe Wrap (Heating), Other (Single Family)     | 1.4  |
| Pipe Wrap (Heating), Gas (Attached Low Rise)   | 0.16 |
| Pipe Wrap (Heating), Oil (Attached Low Rise)   | 0.16 |
| Pipe Wrap (Heating), Other (Attached Low Rise) | 0.16 |
| Pipe Wrap (Heating), Gas (High Rise)           | 0.16 |
| Pipe Wrap (Heating), Oil (High Rise)           | 0.16 |
| Pipe Wrap (Heating), Other (High Rise)         | 0.16 |

**Baseline Efficiency:**

The baseline efficiency case is the existing equipment prior to the installation of additional insulation,

**High Efficiency:**

The high efficiency case includes pipe wrap.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Pipe Wrap (Heating) | RES_CD          | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Heating) | RES_CD          | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

The realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Coincidence factors are set to zero since there are no electric savings for this measure.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>3</sup>

| Measure Name                            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Pipe Wrap (Heating) (Single Family)     | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Pipe Wrap (Heating) (Attached Low Rise) | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Pipe Wrap (Heating) (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

There are no non energy impacts identified for this measure.

**Endnotes:**

**1** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. For Attached Low Rise and High Rise: Savings assumptions for Multifamily programs are from National Grid program vendor.

[2018 Navigant HES Impact Evaluation](#)

**2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**3** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.41. HVAC - Programmable Thermostat

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-PT                              |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of a programmable thermostat, which gives the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.

### BCR Measure IDs:

| Measure Name                                                      | Core Initiative                           | BCR Measure ID |
|-------------------------------------------------------------------|-------------------------------------------|----------------|
| Programmable Thermostat, Electric (Single Family)                 | Residential Coordinated Delivery (RES_CD) | EA2a059        |
| Programmable Thermostat, Gas (Single Family)                      | Residential Coordinated Delivery (RES_CD) | EA2a060        |
| Programmable Thermostat, Oil (Single Family)                      | Residential Coordinated Delivery (RES_CD) | EA2a061        |
| Programmable Thermostat, Other (Single Family)                    | Residential Coordinated Delivery (RES_CD) | EA2a062        |
| Programmable Thermostat, Electric (Attached Low Rise)             | Residential Coordinated Delivery (RES_CD) | EA2a142        |
| Programmable Thermostat, Gas (Attached Low Rise)                  | Residential Coordinated Delivery (RES_CD) | EA2a144        |
| Programmable Thermostat, Oil (Attached Low Rise)                  | Residential Coordinated Delivery (RES_CD) | EA2a145        |
| Programmable Thermostat, Other (Attached Low Rise)                | Residential Coordinated Delivery (RES_CD) | EA2a146        |
| Programmable Thermostat, Electric Resistance, No AC (High Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a230        |
| Programmable Thermostat, Electric Resistance, With AC (High Rise) | Residential Coordinated Delivery (RES_CD) | EA2a231        |
| Programmable Thermostat, AC Only (High Rise)                      | Residential Coordinated Delivery (RES_CD) | EA2a232        |
| Programmable Thermostat, Heat Pump (High Rise)                    | Residential Coordinated Delivery (RES_CD) | EA2a233        |
| Programmable Thermostat, Oil (High Rise)                          | Residential Coordinated Delivery (RES_CD) | EA2a234        |
| Programmable Thermostat, Electric                                 | Residential Retail (RES_RETAIL)           | EA2c054        |

|                                                  |                                           |         |
|--------------------------------------------------|-------------------------------------------|---------|
| Programmable Thermostat, Gas                     | Residential Retail (RES_RETAIL)           | EA2c055 |
| Programmable Thermostat, Oil                     | Residential Retail (RES_RETAIL)           | EA2c056 |
| Programmable Thermostat, Other                   | Residential Retail (RES_RETAIL)           | EA2c057 |
| Programmable Thermostat, Gas (Single Family)     | Residential Coordinated Delivery (RES_CD) | GA2a011 |
| Programmable Thermostat, Gas (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | GA2a056 |
| Programmable Thermostat, Gas (High Rise)         | Residential Coordinated Delivery (RES_CD) | GA2a090 |
| Programmable Thermostat, Gas                     | Residential Retail (RES_RETAIL)           | GA2c029 |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed based on study results<sup>1,2,3</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>4</sup>

| Measure Name                                                      | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|-------------------------------------------------------------------|--------------|-------------|----------------|
| Programmable Thermostat, Electric (Single Family)                 | 278          | 0.19        |                |
| Programmable Thermostat, Gas (Single Family)                      | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Oil (Single Family)                      | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Other (Single Family)                    | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Electric (Attached Low Rise)             | 278          | 0.19        |                |
| Programmable Thermostat, Gas (Attached Low Rise)                  | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Oil (Attached Low Rise)                  | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Other (Attached Low Rise)                | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Electric Resistance, No AC (High Rise)   | 257          | 0.19        |                |
| Programmable Thermostat, Electric Resistance, With AC (High Rise) | 281          | 0.13        |                |
| Programmable Thermostat, AC Only (High Rise)                      | 25           | 0.04        |                |
| Programmable Thermostat, Heat Pump (High Rise)                    | 241          | 0.28        |                |
| Programmable Thermostat, Oil (High Rise)                          |              |             | 2.1            |
| Programmable Thermostat, Gas (High Rise)                          |              |             | 2.1            |
| Programmable Thermostat, Electric                                 | 278          | 0.19        |                |
| Programmable Thermostat, Gas                                      | 27           | 0.04        | 2.1            |
| Programmable Thermostat, Oil                                      | 27           | 0.04        | 2.1            |

|                                |    |      |     |
|--------------------------------|----|------|-----|
| Programmable Thermostat, Other | 27 | 0.04 | 2.1 |
|--------------------------------|----|------|-----|

**Baseline Efficiency:**

The baseline efficiency case is an HVAC system without a programmable thermostat.

**High Efficiency:**

The high efficiency case is an HVAC system that has a programmable thermostat installed.

**Measure Life:**

The measure life is 19 years.<sup>5</sup> For Attached Low Rise and High Rise the measure persistence was estimated to be 69%<sup>6</sup> so the effective measure life is 13 years (19 years \* 69%).

| Measure Name                                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Programmable Thermostat (Single Family)     | RES_CD          | All | 19  | n/a | n/a | 19  |
| Programmable Thermostat (Attached Low Rise) | RES_CD          | All | 19  | n/a | n/a | 13  |
| Programmable Thermostat (High Rise)         | RES_CD          | All | 19  | n/a | n/a | 13  |
| Programmable Thermostat                     | RES_RETAIL      | All | 19  | n/a | n/a | 19  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Programmable Thermostat, Electric (Single Family)     | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |
| Programmable Thermostat, Gas (Single Family)          | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.50             | 0.04             |
| Programmable Thermostat, Oil (Single Family)          | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.50             | 0.04             |
| Programmable Thermostat, Other (Single Family)        | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.50             | 0.04             |
| Programmable Thermostat, Electric (Attached Low Rise) | RES_CD          | All | 0.79 | 1.00            | 1.00             | 1.00             | 1.00             | 0.24             | 0.25             |

|                                                                   |            |     |      |      |      |      |      |      |      |
|-------------------------------------------------------------------|------------|-----|------|------|------|------|------|------|------|
| Programmable Thermostat, Gas (Attached Low Rise)                  | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |
| Programmable Thermostat, Oil (Attached Low Rise)                  | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |
| Programmable Thermostat, Other (Attached Low Rise)                | RES_CD     | All | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |
| Programmable Thermostat, Electric Resistance, No AC (High Rise)   | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.43 |
| Programmable Thermostat, Electric Resistance, With AC (High Rise) | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.06 | 0.45 |
| Programmable Thermostat, AC Only (High Rise)                      | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |
| Programmable Thermostat, Heat Pump (High Rise)                    | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.39 | 0.14 |
| Programmable Thermostat, Oil (High Rise)                          | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | n/a  | n/a  |
| Programmable Thermostat, Gas (High Rise)                          | RES_CD     | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | n/a  | n/a  |
| Programmable Thermostat, Electric                                 | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.24 | 0.25 |
| Programmable Thermostat, Gas                                      | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |
| Programmable Thermostat, Oil                                      | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |
| Programmable Thermostat, Other                                    | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.04 |

**In-Service Rates:**

RCD Single Family and Attached Low Rise in-service rates are blended and based on evaluation results.<sup>7 8</sup> Retail and RCD High Rise assume 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>9</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>10</sup>

| Measure Name                                                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Programmable Thermostat (Single Family) – electric, oil, and other     | RES_CD          | All | 0.13 | 0.12            | 0                | 0.99 |
| Programmable Thermostat (Single Family) – gas                          | RES_CD          | All | 0.25 | 0.12            | 0                | 0.87 |
| Programmable Thermostat (Attached Low Rise) – electric, oil, and other | RES_CD          | All | 0.13 | 0.12            | 0                | 0.99 |
| Programmable Thermostat (Attached Low Rise) - gas                      | RES_CD          | All | 0.25 | 0.12            | 0                | 0.87 |
| Programmable Thermostat (High Rise) – electric, oil and other          | RES_CD          | All | 0.14 | 0               | 0                | 0.86 |
| Programmable Thermostat (High Rise) - gas                              | RES_CD          | All | 0.14 | 0               | 0                | 0.86 |
| Programmable Thermostat – electric, oil, and other                     | RES_RETAIL      | All | 0.13 | 0.12            | 0                | 0.99 |
| Programmable Thermostat – gas                                          | RES_RETAIL      | All | 0.25 | 0.12            | 0                | 0.87 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B. The thermostat NEI values are per household and the PAs adjust the total value by the average number of thermostats per account depending on the initiative.

| Measure Name                                | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Programmable Thermostat (Single Family)     | RES_CD          | All | \$5.45             |                      |                   |                     |                     |                       |
| Programmable Thermostat (Attached Low Rise) | RES_CD          | All | \$5.45             |                      |                   |                     |                     |                       |
| Programmable Thermostat (High Rise)         | RES_CD          | All | \$14.35            |                      |                   |                     |                     |                       |
| Programmable Thermostat                     | RES_RETAIL      | All | \$5.45             |                      |                   |                     |                     |                       |

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**Endnotes:**

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- 1** : Guidehouse Inc (2021) Residential Wi-Fi and Programmable Thermostat Impacts
- 2** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. [2018 Navigant HES Impact Evaluation](#)
- 3** : The Cadmus Group (2012). Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5** : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 6** : The Cadmus Group, Inc. (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 7** : Guidehouse (2021). Virtual Home Energy Assessment Study. [2021 Guidehouse VHEA Report FINAL](#)
- 8** : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)
- 9** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 10** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)



## 1.42. HVAC - Quality Installation (QI) with Duct Modification

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-HVAC-QIDM                            |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

50% reduction in duct leakage from 20% to 10%. This measure may also include duct modifications.

### BCR Measure IDs:

| Measure Name             | Core Initiative                 | BCR Measure ID |
|--------------------------|---------------------------------|----------------|
| QI w/ Duct modifications | Residential Retail (RES_RETAIL) | EA2c107        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on an evaluation study.<sup>1</sup>

### Savings for Quality Installation with Duct Modification:

| Measure Name             | Energy Type | $\Delta$ kWh | $\Delta$ kW |
|--------------------------|-------------|--------------|-------------|
| QI w/ Duct modifications | Electric    | 230          | 0.33        |

### Baseline Efficiency:

The baseline efficiency case is a system with an installation that is inconsistent with manufacturer specifications and may include leaky ducts.

### High Efficiency:

The high efficiency case is a system with an installation that is consistent with manufacturer specifications and may have reduced duct leakage.

### Measure Life:

The measure life is based on evaluation results.<sup>2</sup>

| Measure Name             | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------|-----------------|-----|-----|-----|-----|-----|
| QI w/ Duct modifications | RES_RETAIL      | All | 18  | n/a | n/a | 18  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| OI w/ Duct modifications | RES RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |

### In-Service Rates:

All installations have 100% in service rate.

### Realization Rates:

Realization rates are set to 100% since deemed savings are based on evaluation results.

### Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

### Impact Factors for Calculating Net Savings:

| Measure Name            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------|-----------------|-----|------|-----------------|------------------|------|
| QI w/Duct modifications | RES_RETAIL      | All | 0.34 | 0.12            | 0.10             | 0.88 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| QI w/Duct modifications | RES_RETAIL      | All | \$1.53             |                      |                   |                     |                     |                       |

### Endnotes:

1 : Final Study Results [2021 Guidehouse TRM Final Report](#)

2 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.43. HVAC - Room Air Conditioner

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | RES-PL-ROOMAC                            |
| <b>Market</b>       | Residential                              |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Rebates provided for the purchase of an ENERGY STAR® qualified room air conditioner.

### BCR Measure IDs:

| Measure Name         | Core Initiative                 | BCR Measure ID |
|----------------------|---------------------------------|----------------|
| Room Air Conditioner | Residential Retail (RES_RETAIL) | EA2c086        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on averaged results from the ENERGY STAR appliance calculator, run with inputs for five sizes of units.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name         | kWh | kW   |
|----------------------|-----|------|
| Room Air Conditioner | 36  | 0.05 |

### Baseline Efficiency:

The baseline efficiency case is a unit meeting the current federal standard.<sup>3</sup>

### High Efficiency:

The high efficiency case is an ENERGY STAR® qualified air conditioner.<sup>4</sup>

### Measure Life:

The measure life is 12 years.<sup>5</sup>

| Measure Name         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------|-----------------|-----|-----|-----|-----|-----|
| Room Air Conditioner | RES_RETAIL      | All | 12  | n/a | n/a | 12  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RE <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Room Air Conditioner | RES_RETAIL      | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.50             | 0.04             |

**In-Service Rates:**

All installations are assumed to have 100% in service rate.<sup>6</sup>

**Realization Rates:**

Realization rates are set to 100% since unit savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors based on evaluation results.<sup>8</sup>

**2022**

| Name                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Conditioner | RES_RETAIL      | All | 0.42 | 0.00            | 0.00             | 0.56 |

**2023**

| Name                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Conditioner | RES_RETAIL      | All | 0.46 | 0.00            | 0.00             | 0.54 |

**2024**

| Name                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Conditioner | RES_RETAIL      | All | 0.48 | 0.00            | 0.00             | 0.52 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 1 : EPA (2009). Lifecycle Cost Estimate for Energy Star Room Air Conditioners. [EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Room Air Conditioner](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : <https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32>
- 4 : [https://www.energystar.gov/products/heating\\_cooling/air\\_conditioning\\_room/key\\_product\\_criteria](https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria)
- 5 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 6 : NMR Group Inc. (2021). Residential Products In Service Rates Memo. [2021 NMR Products ISR](#)

- 7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 8** : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

## 1.44. Hot Water - Condensing Water Heater

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-CWH    |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

Condensing water heaters recover energy by using either a larger heat exchanger or a second heat exchanger to reduce the flue-gas temperature to the point that water vapor condenses, thus releasing even more energy.

### BCR Measure IDs:

| Measure Name                         | Core Initiative                 | BCR Measure ID |
|--------------------------------------|---------------------------------|----------------|
| Water Heater, Gas Storage Condensing | Residential Retail (RES_RETAIL) | GA2c025        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name                  | $\Delta$ MMBtu | $\Delta$ kWh | $\Delta$ kW |
|-------------------------------|----------------|--------------|-------------|
| Water Heater, Condensing, Gas | 7.0            | -43          | -0.01       |

There is an electric penalty associated with the gas storage condensing water heaters to account for increased electrical consumption for powered damper and electronic (not manual) pilot ignition.<sup>2</sup>

$\Delta$ kWh = Average annual energy reduction per unit: -43.0 kWh

$\Delta$ kW = Average demand reduction per unit: -0.01 kW

### Baseline Efficiency:

The baseline efficiency case is a standalone tank water heater with an UEF of 0.60.

### High Efficiency:

The high efficiency case is a condensing water heater with a UEF  $\geq$  0.80.

### Measure Life:

The measure life is 15 years.<sup>3</sup>

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| Water Heater, Condensing, Gas | RES_RETAIL      | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Water Heater, Condensing, Gas | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

**In-Service Rates**

In-service rates are set to 100% since all PAs verify equipment installation.

**Realization Rates**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-gross is based on evaluation results.<sup>5</sup>

| Measure Name                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Water Heater, Condensing, Gas | RES_RETAIL      | All | 0.36 | 0.12            | 0.00             | 0.76 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Water Heater, Condensing, Gas | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task
- 2 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task
- 3 : DOE (2008). ENERGY STAR® Residential Water Heaters: Final Criteria Analysis. Prepared for the DOE; Page 10 [DOE 2008 ENERGY STAR Residential Water Heaters Final Criteria Analysis](#)
- 4 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5 : NTG results came from the following study: [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.45. Hot Water - Faucet Aerator

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-FA     |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

An existing faucet aerator with a high flow rate is replaced with a new low flow aerator.

### BCR Measure IDs:

| Measure Name                                 | Core Initiative                           | BCR Measure ID |
|----------------------------------------------|-------------------------------------------|----------------|
| Faucet Aerator, Electric (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a051        |
| Faucet Aerator, Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a052        |
| Faucet Aerator, Oil (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a053        |
| Faucet Aerator, Other (Single Family)        | Residential Coordinated Delivery (RES_CD) | EA2a054        |
| Faucet Aerator, Electric (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a128        |
| Faucet Aerator, Gas (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a129        |
| Faucet Aerator, Oil (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a130        |
| Faucet Aerator, Other (Attached Low Rise)    | Residential Coordinated Delivery (RES_CD) | EA2a131        |
| Faucet Aerator, Electric (High Rise)         | Residential Coordinated Delivery (RES_CD) | EA2a216        |
| Faucet Aerator, Gas (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a217        |
| Faucet Aerator, Oil (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a218        |
| Faucet Aerator, Other (High Rise)            | Residential Coordinated Delivery (RES_CD) | EA2a219        |
| Faucet Aerator, Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | GA2a007        |
| Faucet Aerator, Gas (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | GA2a052        |
| Faucet Aerator, Gas (High Rise)              | Residential Coordinated Delivery (RES_CD) | GA2a086        |



### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtus savings are deemed based on study results.<sup>1 2</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

| Measure Name                                 | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|----------------------------------------------|--------------|-------------|----------------|
| Faucet Aerator, Electric (Single Family)     | 43.0         | 0.01        |                |
| Faucet Aerator, Gas (Single Family)          |              |             | 0.21           |
| Faucet Aerator, Oil (Single Family)          |              |             | 0.22           |
| Faucet Aerator, Other (Single Family)        |              |             | 0.21           |
| Faucet Aerator, Electric (Attached Low Rise) | 43.0         | 0.01        |                |
| Faucet Aerator, Gas (Attached Low Rise)      |              |             | 0.21           |
| Faucet Aerator, Oil (Attached Low Rise)      |              |             | 0.22           |
| Faucet Aerator, Other (Attached Low Rise)    |              |             | 0.21           |
| Faucet Aerator, Electric (High Rise)         | 97.0         | 0.02        |                |
| Faucet Aerator, Gas (High Rise)              |              |             | 0.86           |
| Faucet Aerator, Oil (High Rise)              |              |             | 0.86           |
| Faucet Aerator, Other (High Rise)            |              |             | 0.86           |

### Baseline Efficiency:

The baseline efficiency case is the existing faucet aerator with a high flow.

### High Efficiency:

The high efficiency case is a low flow faucet aerator.

### Measure Life:

The measure life is 7 years.

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Faucet Aerator | RES_CD          | All | 7   | n/a | n/a | 7   |

### Other Resource Impacts:

Residential water savings for faucet aerators is 332 gallons per unit.<sup>4</sup>

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Faucet Aerator (Single Family)     | RES_CD          | All | 0.74 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Faucet Aerator (Attached Low Rise) | RES_CD          | All | 0.74 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Faucet Aerator (High Rise)         | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |

### **In-Service Rates:**

For Single Family and Low Rise in service rates are blended and based on evaluation results.<sup>5 6</sup> All high rise installations have 100% in service rate since programs include verification of equipment installations.

### **Realization Rates:**

Realization rates are set to 100% for deemed measures.

### **Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

### **Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>8</sup>

| Measure Name                       | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Faucet Aerator (Single Family)     | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Faucet Aerator (Attached Low Rise) | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Faucet Aerator (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |

### **Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Faucet Aerator (Single Family)     | RES_CD          | All |                    |                      |                   |                     |                     |                       |
| Faucet Aerator (Attached Low Rise) | RES_CD          | All |                    |                      |                   |                     |                     |                       |
| Faucet Aerator (High Rise)         | RES_CD          | All | \$0.58             |                      |                   |                     |                     |                       |

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**Endnotes:**

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**1** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.

[2018 Navigant HES Impact Evaluation](#)

**2** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**4** : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.

[Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

**5** : Guidehouse (2021). Virtual Home Energy Assessment Study. [2021 Guidehouse VHEA Report FINAL](#)

**6** : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)

**7** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**8** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures:

Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.46. Hot Water - Heat Pump Water Heater

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-HPWH   |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Time of Sale  |
| <b>Category</b>     | Water Heating |

### Measure Description:

Installation of a heat pump water heater (HPWH) instead of an electric resistance water heater.

### BCR Measure IDs:

| Measure Name                                                     | Core Initiative                 | BCR Measure ID |
|------------------------------------------------------------------|---------------------------------|----------------|
| Heat Pump Water Heater displacing Existing Water Heater, Oil     | Residential Retail (RES_RETAIL) | EA2c286        |
| Heat Pump Water Heater displacing Existing Water Heater, Propane | Residential Retail (RES_RETAIL) | EA2c287        |
| Heat Pump Water Heater displacing Existing Water Heater, Gas     | Residential Retail (RES_RETAIL) | GA2c077        |
| Water Heater, Heat Pump, <55 gallon, Energy Star                 | Residential Retail (RES_RETAIL) | EA2c018        |
| Water Heater, Heat Pump, >55 gallon, UEF 2.70                    | Residential Retail (RES_RETAIL) | EA2c019        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results <sup>1</sup>

| Measure Name                                     | Water Heating Savings |                | Heating Savings (Penalty) |                                               | Total Savings |                 |             |                                            |
|--------------------------------------------------|-----------------------|----------------|---------------------------|-----------------------------------------------|---------------|-----------------|-------------|--------------------------------------------|
|                                                  | $\Delta$ kWh          | $\Delta$ MMBTU | $\Delta$ kWh              | $\Delta$ MMBTU                                | $\Delta$ kWh  | Max Load Factor | $\Delta$ kW | $\Delta$ MMBTU                             |
| Water Heater, Heat Pump, <55 gallon, Energy Star | 1799                  | 0              | -86.3                     | Gas = -0.50<br>Oil = -0.10<br>Propane = -0.07 | 1712          | 0.00025         | 0.43        | Gas = 0.50<br>Oil = 0.10<br>Propane = 0.07 |
| Water Heater, Heat Pump, >55 gallon, UEF 2.70    | 360                   | 0              | 0                         | 0                                             | 360           | 0.00025         | 0.09        | 0                                          |

|                                                                  |       |      |   |       |       |         |       |      |
|------------------------------------------------------------------|-------|------|---|-------|-------|---------|-------|------|
| Heat Pump Water Heater displacing Existing Water Heater, Oil     | -1130 | 20.0 | 0 | -0.67 | -1130 | 0.00025 | -0.28 | 19.3 |
| Heat Pump Water Heater displacing Existing Water Heater, Propane | -831  | 17.1 | 0 | -0.67 | -831  | 0.00025 | -0.21 | 16.4 |
| Heat Pump Water Heater displacing Existing Water Heater, Gas     | -831  | 17.1 | 0 | -0.67 | -831  | 0.00025 | -0.21 | 16.4 |

**Baseline Efficiency:**

The baseline efficiency case is for the Water Heater, Heat Pump <55 gallon is a new, baseline code efficiency electric resistance hot water heater. The baseline efficiency case for the Water Heater, Heat Pump > 55 gallon is a new, baseline code heat pump water heater. The baseline for the oil water heater is a weighted average of an oil tankless coil water heater (75%) and a baseline code standard oil tank water heater (25%). The baseline for the propane water heater is a baseline code standard propane tank water heater with a UEF =0.62. The baseline for the gas water heater is a baseline code standard natural gas tank water heater with a UEF =0.62.

**High Efficiency:**

The high efficiency case for the < 55 gallon and both of the oil and propane to high efficiency HPWH is a 2.0 UEF or greater HPWH and the > 55 gallon HPWH is a 2.7 UEF or greater HPWH. Savings are based on 2020 production.

**Measure Life:**

The measure life is 13 years.<sup>2</sup>

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Heat Pump Water Heater | IE_CD           | All | 13  | n/a | n/a | 13  |

**Other Resource Impacts:**

There are heating fuel penalties associated with the <=55 gallon heat pump water heater to account for additional consumption for space heating when replacing a standard electric water heater.<sup>3</sup>

- ΔMMBtu = Average annual fuel reduction per unit = -0.50 MMBtu (oil)
- ΔMMBtu = Average annual fuel reduction per unit = -0.10 MMBtu (natural gas)
- ΔMMBtu = Average annual fuel reduction per unit = -0.07 MMBtu (propane)

There are fuel savings associated with going from either an oil water heating system or a propane water heating system to a HPWH. The penalties shown above are also included in the savings values for the two measures shown below. Savings for oil is reduced by 0.67 MMBTU and similarly are reduced for propane/natural gas with the same 0.67 MMBTU value.

Since the baseline for Water Heater, Heat Pump, >55 gallon, UEF 2.70 is already a heat pump water heater, this penalty would be experienced for both the baseline and the energy efficiency heat pump and due to this there is no heating penalty included.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure                                                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Water Heater, Heat Pump, <55 gallon, Energy Star                 | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Water Heater, Heat Pump, >55 gallon, UEF 2.70                    | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Heat Pump Water Heater displacing Existing Water Heater, Oil     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Heat Pump Water Heater displacing Existing Water Heater, Propane | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Heat Pump Water Heater displacing Existing Water Heater, Gas     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

### In-Service Rates:

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

### Realization Rates:

Realization rates are set to 100% since deemed savings are based on evaluation results.

### Coincidence Factors:

Coincidence factors are based on evaluation results.

### Impact Factors for Calculating Net Savings:

Impact factors for net savings:<sup>3</sup>

| Measure Name                                                     | Core Initiative                 | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------------------|---------------------------------|-----|------|-----------------|------------------|------|
| Water Heater, Heat Pump, <55 gallon, Energy Star                 | Residential Retail (RES_RETAIL) | All | 0.30 | 0.12            | 0.00             | 0.82 |
| Water Heater, Heat Pump, >55 gallon, UEF 2.70                    | Residential Retail (RES_RETAIL) | All | 0.30 | 0.12            | 0.00             | 0.82 |
| Heat Pump Water Heater displacing Existing Water Heater, Oil     | Residential Retail (RES_RETAIL) | All | 0.30 | 0.12            | 0.00             | 0.82 |
| Heat Pump Water Heater displacing Existing Water Heater, Propane | Residential Retail (RES_RETAIL) | All | 0.30 | 0.12            | 0.00             | 0.82 |

|                                                              |                                 |     |      |      |      |      |
|--------------------------------------------------------------|---------------------------------|-----|------|------|------|------|
| Heat Pump Water Heater displacing Existing Water Heater, Gas | Residential Retail (RES_RETAIL) | All | 0.36 | 0.12 | 0.00 | 0.76 |
|--------------------------------------------------------------|---------------------------------|-----|------|------|------|------|

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                                     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Water Heater, Heat Pump, <55 gallon, Energy Star                 | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |
| Water Heater, Heat Pump, >55 gallon, UEF 2.70                    | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |
| Heat Pump Water Heater displacing Existing Water Heater, Oil     | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |
| Heat Pump Water Heater displacing Existing Water Heater, Propane | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |
| Heat Pump Water Heater displacing Existing Water Heater, Gas     | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |

### Endnotes:

- 1 : Guidehouse 2021 - Savings Calculations [MA21R39-E-HPWHQH\\_Task 3 Findings Spreadsheet- 31Aug2021](#)  
2 : Guidehouse 2021 - Savings Calculations [MA21R39-E-HPWHQH\\_Task 3 Findings Spreadsheet- 31Aug2021](#)  
3 : Guidehouse (2021) - NTG Study [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.47. Hot Water - Indirect Water Heater

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-IWH    |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

Indirect water heaters use a storage tank that is heated by the main boiler. The energy stored by the water tank allows the boiler to turn off and on less often, saving considerable energy.

### BCR Measure IDs:

| Measure Name                  | Core Initiative                 | BCR Measure ID |
|-------------------------------|---------------------------------|----------------|
| Water Heater, Indirect, Oil   | Residential Retail (RES_RETAIL) | EA2c015        |
| Water Heater, Indirect, Other | Residential Retail (RES_RETAIL) | EA2c016        |
| Water Heater, Indirect, Gas   | Residential Retail (RES_RETAIL) | GA2c028        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name                  | $\Delta$ MMBtu |
|-------------------------------|----------------|
| Water Heater, Indirect, Oil   | 4.7            |
| Water Heater, Indirect, Other | 4.0            |
| Water Heater, Indirect, Gas   | 4.0            |

### Baseline Efficiency:

The baseline efficiency case is the existing water heater.

### High Efficiency:

The high efficiency case is an indirect water heater attached to an ENERGY STAR® rated forced hot water boiler.



**Measure Life:**

The measure life is 20 years.<sup>2</sup>

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Water Heater, Indirect | RES_RETAIL      | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Water Heater, Indirect | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on multiple evaluation results.<sup>3</sup>

| Measure Name                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Water Heater, Indirect, Oil   | RES_RETAIL      | All | 0.30 | 0.12            | 0.00             | 0.82 |
| Water Heater, Indirect, Other | RES_RETAIL      | All | 0.30 | 0.12            | 0.00             | 0.82 |
| Water Heater, Indirect, Gas   | RES_RETAIL      | All | 0.36 | 0.12            | 0.00             | 0.76 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Water Heater, Indirect, Oil   | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |
| Water Heater, Indirect, Other | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |

|                                |            |     |        |  |  |  |  |  |
|--------------------------------|------------|-----|--------|--|--|--|--|--|
| Water Heater,<br>Indirect, Gas | RES_RETAIL | All | \$0.70 |  |  |  |  |  |
|--------------------------------|------------|-----|--------|--|--|--|--|--|

**Endnotes:**

**1** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.

[2018 Navigant HES Impact Evaluation](#)

**2** : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts.

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

**3** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures

Workbook [2021 Guidehouse MA Res NTG Final Report](#)

## 1.48. Hot Water - Low-Flow Showerhead

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-S      |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

An existing showerhead with a high flow rate is replaced with a new low flow showerhead.

### BCR Measure IDs:

| Measure Name                                      | Core Initiative                           | BCR Measure ID |
|---------------------------------------------------|-------------------------------------------|----------------|
| Low-Flow Showerhead, Electric (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a055        |
| Low-Flow Showerhead, Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a056        |
| Low-Flow Showerhead, Oil (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a057        |
| Low-Flow Showerhead, Other (Single Family)        | Residential Coordinated Delivery (RES_CD) | EA2a058        |
| Low-Flow Showerhead, Electric (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a132        |
| Low-Flow Showerhead, Gas (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a133        |
| Low-Flow Showerhead, Oil (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a134        |
| Low-Flow Showerhead, Other (Attached Low Rise)    | Residential Coordinated Delivery (RES_CD) | EA2a135        |
| Low-Flow Showerhead, Electric (High Rise)         | Residential Coordinated Delivery (RES_CD) | EA2a220        |
| Low-Flow Showerhead, Gas (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a221        |
| Low-Flow Showerhead, Oil (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a222        |
| Low-Flow Showerhead, Other (High Rise)            | Residential Coordinated Delivery (RES_CD) | EA2a223        |

|                                              |                                           |         |
|----------------------------------------------|-------------------------------------------|---------|
| Low-Flow Showerhead, Gas (Single Family)     | Residential Coordinated Delivery (RES_CD) | GA2a008 |
| Low-Flow Showerhead, Gas (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | GA2a053 |
| Low-Flow Showerhead, Gas (High Rise)         | Residential Coordinated Delivery (RES_CD) | GA2a087 |
| Low-Flow Showerhead, Gas                     | Residential Retail (RES_RETAIL)           | GA2c034 |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed based on study results.<sup>1 2</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

| Measure Name                                      | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|---------------------------------------------------|--------------|-------------|----------------|
| Low-Flow Showerhead, Electric (Single Family)     | 187.0        | 0.05        |                |
| Low-Flow Showerhead, Gas (Single Family)          |              |             | 0.92           |
| Low-Flow Showerhead, Oil (Single Family)          |              |             | 0.98           |
| Low-Flow Showerhead, Other (Single Family)        |              |             | 0.92           |
| Low-Flow Showerhead, Electric (Attached Low Rise) | 187.0        | 0.05        |                |
| Low-Flow Showerhead, Gas (Attached Low Rise)      |              |             | 0.92           |
| Low-Flow Showerhead, Oil (Attached Low Rise)      |              |             | 0.98           |
| Low-Flow Showerhead, Other (Attached Low Rise)    |              |             | 0.92           |
| Low-Flow Showerhead, Electric (High Rise)         | 129.0        | 0.03        |                |
| Low-Flow Showerhead, Gas (High Rise)              |              |             | 1.14           |
| Low-Flow Showerhead, Oil (High Rise)              |              |             | 1.14           |
| Low-Flow Showerhead, Other (High Rise)            |              |             | 1.14           |
| Low-Flow Showerhead, Gas (Single Family)          |              |             | 1.2            |

### Baseline Efficiency:

The baseline efficiency case is the existing showerhead with a baseline flow rate of 2.5 GPM.

### High Efficiency:

The high efficiency case is a low flow showerhead having a maximum flow rate between 1.5 and 1.7 GPM.

**Measure Life:**

The measure life is 15 years.<sup>4</sup>

| Measure Name        | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|---------------------|----------------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead | RES_CD<br>RES_RETAIL | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

Water savings for Retail and Single Family are 2,401 gallons per unit and for Attached Low Rise and High Rise water savings are 2,165 gallons per unit.<sup>5</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead, Electric (Single Family)     | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | 0.15             | 0.42             |
| Low-Flow Showerhead, Gas (Single Family)          | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Oil (Single Family)          | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Other (Single Family)        | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Electric (Attached Low Rise) | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | 0.15             | 0.42             |
| Low-Flow Showerhead, Gas (Attached Low Rise)      | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Oil (Attached Low Rise)      | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Other (Attached Low Rise)    | RES_CD          | All | 0.66 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Electric (High Rise)         | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | 0.15             | 0.42             |
| Low-Flow Showerhead, Gas (High Rise)              | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Oil (High Rise)              | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

|                                        |            |     |      |      |      |     |     |     |     |
|----------------------------------------|------------|-----|------|------|------|-----|-----|-----|-----|
| Low-Flow Showerhead, Other (High Rise) | RES_CD     | All | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Low-Flow Showerhead, Gas               | RES_RETAIL | All | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |

**In-Service Rates:**

For Single Family and Low Rise in service rates are blended and based on evaluation results.<sup>6 7</sup> All High Rise installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>8</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>9</sup>

| Measure Name                            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Low-Flow Showerhead (Single Family)     | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Low-Flow Showerhead (Attached Low Rise) | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Low-Flow Showerhead (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Low-Flow Showerhead                     | RES_RETAIL      | All | 0.04 | 0.12            | 0.00             | 1.08 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead (Single Family)     | RES_CD          | All |                    | \$0.03               |                   |                     |                     |                       |
| Low-Flow Showerhead (Attached Low Rise) | RES_CD          | All |                    | \$0.03               |                   |                     |                     |                       |
| Low-Flow Showerhead (High Rise)         | RES_CD          | All | \$0.58             |                      |                   |                     |                     |                       |

|                                        |            |     |  |        |  |  |  |  |
|----------------------------------------|------------|-----|--|--------|--|--|--|--|
| Low-Flow Showerhead<br>(Single Family) | RES_RETAIL | All |  | \$0.03 |  |  |  |  |
|----------------------------------------|------------|-----|--|--------|--|--|--|--|

**Endnotes:**

- 1 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. [2018 Navigant HES Impact Evaluation](#)
- 2 : The Cadmus Group (2012). Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 4 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 5 : Staff calculations based on the methodology from The Cadmus Group, Inc. (2012). Home Energy Services Impact Evaluation. [CADMUS 2012 HES Impact Evaluation Report](#)
- 6 : Guidehouse (2021). Virtual Home Energy Assessment Study. [2021 Guidehouse VHEA Report FINAL](#)
- 7 : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)
- 8 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 9 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.49. Hot Water - Low-Flow Showerhead with Thermostatic Valve

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-STV    |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

An existing showerhead is replaced with a low-flow showerhead with an integrated thermostatic shut-off valve (TSV).

### BCR Measure IDs:

| Measure Name                                       | Core Initiative                           | BCR Measure ID |
|----------------------------------------------------|-------------------------------------------|----------------|
| Low-Flow Showerhead with TSV, Electric (High Rise) | Residential Coordinated Delivery (RES_CD) | EA2a224        |
| Low-Flow Showerhead with TSV, Oil (High Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a225        |
| Low-Flow Showerhead with TSV, Other (High Rise)    | Residential Coordinated Delivery (RES_CD) | EA2a226        |
| Low-Flow Showerhead with TSV, Electric             | Residential Retail (RES_RETAIL)           | EA2c078        |
| Low-Flow Showerhead with TSV, Gas                  | Residential Retail (RES_RETAIL)           | EA2c079        |
| Low-Flow Showerhead with TSV, Oil                  | Residential Retail (RES_RETAIL)           | EA2c080        |
| Low-Flow Showerhead with TSV, Other                | Residential Retail (RES_RETAIL)           | EA2c081        |
| Low-Flow Showerhead with TSV, Gas (High Rise)      | Residential Coordinated Delivery (RES_CD) | GA2a088        |
| Low-Flow Showerhead with TSV, Gas                  | Residential Retail (RES_RETAIL)           | GA2c032        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on engineering analysis.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                                       | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|----------------------------------------------------|--------------|-------------|----------------|
| Low-Flow Showerhead with TSV, Gas (High Rise)      |              |             | 1.41           |
| Low-Flow Showerhead with TSV, Electric (High Rise) | 183          | 0.05        |                |



|                                                 |     |      |      |
|-------------------------------------------------|-----|------|------|
| Low-Flow Showerhead with TSV, Oil (High Rise)   |     |      | 1.44 |
| Low-Flow Showerhead with TSV, Other (High Rise) |     |      | 1.41 |
| Low-Flow Showerhead with TSV, Electric          | 247 | 0.06 |      |
| Low-Flow Showerhead with TSV, Gas               |     |      | 1.22 |
| Low-Flow Showerhead with TSV, Oil               |     |      | 1.32 |
| Low-Flow Showerhead with TSV, Other             |     |      | 1.22 |

### Baseline Efficiency:

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

### High Efficiency:

The high efficiency case is a low-flow showerhead (1.7 GPM) with integrated thermostatically actuated valve.

### Measure Life:

The measure life is 15 years.<sup>3</sup>

| Measure Name                 | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|------------------------------|----------------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead with TSV | RES_CD<br>RES_RETAIL | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

Water savings for Low-Flow Showerheads with TSV in RCD is 2,723 gallons per unit. Water savings for Low-Flow Showerheads with TSV in Res Retail is 3,022 gallons per unit.<sup>4</sup>

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                 | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead with TSV | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Low-Flow Showerhead with TSV | RES_RETAIL      | All | 0.78 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

### In-Service Rates:

In-Service rate for Res Retail is based on evaluation results.<sup>5</sup>

### Realization Rates:

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>7 8</sup>

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Low-Flow Showerhead with TSV (High Rise) | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Low-Flow Showerhead with TSV             | RES_RETAIL      | All | 0.03 | 0.0             | 0.00             | 0.97 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead with TSV (High Rise) | RES_CD          | All | \$0.58             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 4 : National\_Grid\_2014\_ShowerStart\_Savings\_Final\_2015-2-9  
[National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 5 : NMR Group Inc. (2021). Residential Products In Service Rates Memo. [2021 NMR Products ISR](#)
- 6 : Navigant Consulting (2018). Demand Impact Model Update.  
[2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 7 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)
- 8 : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

## 1.50. Hot Water - On Demand/Tankless Water Heater

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-ODTWH  |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

Tankless water heaters circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank.

### BCR Measure IDs:

| Measure Name                     | Core Initiative                 | BCR Measure ID |
|----------------------------------|---------------------------------|----------------|
| Water Heater, On-Demand, Other   | Residential Retail (RES_RETAIL) | EA2c017        |
| Water Heater, On Demand Tankless | Residential Retail (RES_RETAIL) | GA2c027        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results<sup>1</sup>. For gas the savings have been adjusted to reflect the mix of replace on failure and early replacement based. There is an electric penalty associated with the gas on-demand tankless water heater to account for additional electrical consumption for power venting and electronic pilot ignition.

| Measure Name                   | $\Delta$ kWh | $\Delta$ kW <sup>2</sup> | $\Delta$ MMBtu |
|--------------------------------|--------------|--------------------------|----------------|
| Water Heater, On Demand, Gas   | -43.0        | -0.01                    | 7.0            |
| Water Heater, On-Demand, Other | -43.0        | -0.01                    | 5.4            |

### Baseline Efficiency:

The baseline efficiency case is a standalone tank water heater with a 0.63 UEF. For the early retirement portion, the baseline efficiency is an existing 0.60 UEF standalone water heater.<sup>3</sup>

### High Efficiency:

The high efficiency case is an On Demand tankless water heater with an UEF  $\geq$  0.87

### Measure Life:

The measure life is 19 years for gas equipment<sup>3</sup> and 20 years for propane equipment

| Measure Name                   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------|-----------------|-----|-----|-----|-----|-----|
| Water Heater, On Demand, Gas   | RES_RETAIL      | All | 20  | n/a | n/a | 19  |
| Water Heater, On-Demand, Other | RES_RETAIL      | All | 20  | n/a | n/a | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measures.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                   | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Water Heater, On Demand, Gas   | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Water Heater, On Demand, Other | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

Realization rates are set to 100% for deemed measures.

### Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.<sup>5</sup>

| Measure Name                   | Core Initiative | PA  | FR   | SOP  | SONP | NTG  |
|--------------------------------|-----------------|-----|------|------|------|------|
| Water Heater, On Demand, Gas   | RES_RETAIL      | All | 0.36 | 0.12 | 0.00 | 0.76 |
| Water Heater, On-Demand, Other | RES_RETAIL      | All | 0.30 | 0.12 | 0.00 | 0.82 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>67</sup>

| Measure Name                   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Water Heater, On Demand, Gas   | RES_RETAIL      | All | \$1.23             |                      |                   |                     |                     |                       |
| Water Heater, On Demand, Other | RES_RETAIL      | All | \$0.70             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1** : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task
- 2** : Demand savings were calculated taking the gross energy savings \* the peak max load factor (-43\*0.00025 = -0.01) using the results from the following study: [2020 Guidehouse Residential Baseline Phase 4](#)
- 3** : Early Retirement baseline is considered to be the high draw value from the following source. [2021 Guidehouse TRM Final Report](#)
- 3** : DOE (2008). Energy Star Residential Water Heaters: Final Criteria Analysis and The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing. The calculation of the adjustment can be found in MA PAs (2021). 2020 Annual Report Gas HVAC and Water Heating Calculations Workbook. [MA PAs 2020 Annual Report Gas HVAC WH Calculations GH 2021-03-08](#)
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)
- 6** : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for the Massachusetts Program Administrators. Adjusted based on NMR Group, Inc. (2013) Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)
- 7** : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. Prepared for the Massachusetts Program Administrators. Adjusted based on NMR Group, Inc. (2013) Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure. [NMR 2013 Residential HVAC Replace On Failure NEIs](#)

## 1.51. Hot Water - Pipe Wrap (Water Heating)

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-PW     |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

Installation of DHW pipe wraps.

### BCR Measure IDs:

| Measure Name                                            | Core Initiative                           | BCR Measure ID |
|---------------------------------------------------------|-------------------------------------------|----------------|
| Pipe Wrap (Water Heating), Electric (Single Family)     | Residential Coordinated Delivery (RES_CD) | EA2a044        |
| Pipe Wrap (Water Heating), Gas (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a045        |
| Pipe Wrap (Water Heating), Oil (Single Family)          | Residential Coordinated Delivery (RES_CD) | EA2a046        |
| Pipe Wrap (Water Heating), Other (Single Family)        | Residential Coordinated Delivery (RES_CD) | EA2a047        |
| Pipe Wrap (Water Heating), Electric (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a121        |
| Pipe Wrap (Water Heating), Gas (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a122        |
| Pipe Wrap (Water Heating), Oil (Attached Low Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a123        |
| Pipe Wrap (Water Heating), Other (Attached Low Rise)    | Residential Coordinated Delivery (RES_CD) | EA2a124        |
| Pipe Wrap (Water Heating), Electric (High Rise)         | Residential Coordinated Delivery (RES_CD) | EA2a209        |
| Pipe Wrap (Water Heating), Gas (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a210        |
| Pipe Wrap (Water Heating), Oil (High Rise)              | Residential Coordinated Delivery (RES_CD) | EA2a211        |
| Pipe Wrap (Water Heating), Other (High Rise)            | Residential Coordinated Delivery (RES_CD) | EA2a212        |

|                                                    |                                           |         |
|----------------------------------------------------|-------------------------------------------|---------|
| Pipe Wrap (Water Heating), Gas (Single Family)     | Residential Coordinated Delivery (RES_CD) | GA2a005 |
| Pipe Wrap (Water Heating), Gas (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | GA2a050 |
| Pipe Wrap (Water Heating), Gas (High Rise)         | Residential Coordinated Delivery (RES_CD) | GA2a084 |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed based on study results where unit is a household with pipe wrap installed on hot water pipes.<sup>1 2</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

Savings for Pipe Wrap (Water Heating):

| Measure Name                                            | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|---------------------------------------------------------|--------------|-------------|----------------|
| Pipe Wrap (Water Heating), Electric (Single Family)     | 28           | 0.01        |                |
| Pipe Wrap (Water Heating), Gas (Single Family)          |              |             | 0.29           |
| Pipe Wrap (Water Heating), Oil (Single Family)          |              |             | 0.20           |
| Pipe Wrap (Water Heating), Other (Single Family)        |              |             | 0.30           |
| Pipe Wrap (Water Heating), Electric (Attached Low Rise) | 28           | 0.01        |                |
| Pipe Wrap (Water Heating), Gas (Attached Low Rise)      |              |             | 0.29           |
| Pipe Wrap (Water Heating), Oil (Attached Low Rise)      |              |             | 0.20           |
| Pipe Wrap (Water Heating), Other (Attached Low Rise)    |              |             | 0.30           |
| Pipe Wrap (Water Heating), Electric (High Rise)         | 129          | 0.03        |                |
| Pipe Wrap (Water Heating), Gas (High Rise)              |              |             | 1.14           |
| Pipe Wrap (Water Heating), Oil (High Rise)              |              |             | 1.14           |
| Pipe Wrap (Water Heating), Other (High Rise)            |              |             | 1.14           |

### Baseline Efficiency:

The baseline efficiency case is the existing hot water equipment.

### High Efficiency:

The high efficiency case includes pipe wrap.

### Measure Life:

The measure life is 15 years.<sup>4</sup>

| PA  | Measure Name              | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----|---------------------------|-----------------|-----|-----|-----|-----|-----|
| All | Pipe Wrap (Water Heating) | RES_CD          | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Water Heating), Electric (Single Family)     | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Pipe Wrap (Water Heating), Gas (Single Family)          | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Oil (Single Family)          | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Other (Single Family)        | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Electric (Attached Low Rise) | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Pipe Wrap (Water Heating), Gas (Attached Low Rise)      | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Oil (Attached Low Rise)      | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Other (Attached Low Rise)    | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Electric (High Rise)         | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Pipe Wrap (Water Heating), Gas (High Rise)              | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Oil (High Rise)              | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Other (High Rise)            | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |



**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

The realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>6</sup>

| Measure Name                                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Pipe Wrap (Water Heating) (Single Family)     | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Pipe Wrap (Water Heating) (Attached Low Rise) | RES_CD          | All | 0.04 | 0.12            | 0.00             | 1.08 |
| Pipe Wrap (Water Heating) (High Rise)         | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

**1** : The Cadmus Group, Inc. (2015). Massachusetts Low Income Multifamily Impact Evaluation.

[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)

**2** : Navigant Consulting (2018). HES Impact Evaluation. [2018 Navigant HES Impact Evaluation](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**4** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**6** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.52. Hot Water - Solar Hot Water

|                     |                        |
|---------------------|------------------------|
| <b>Measure Code</b> | RES-S-HW               |
| <b>Market</b>       | Residential            |
| <b>Program Type</b> | Retrofit, Time of Sale |
| <b>Category</b>     | Water Heating          |

### Measure Description:

Installation of Solar Hot Water in a residence with existing electric hot water.

### BCR Measure IDs:

| Measure Name    | Core Initiative                 | BCR Measure ID |
|-----------------|---------------------------------|----------------|
| Solar Hot Water | Residential Retail (RES_RETAIL) | EA2c340        |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = [WHkwh\_base] - [(HWHDkwh) * (1 - \%SHWdesign)] / (\%WHsupp)]$$

Where

WHkwh\_base = Federal standards for maximum allowable energy consumption.

HWHDkwh = The total household water heating demand in kWh.

%SHWdesign = The design percent of household water heating demand met by the solar hot water system.

%WHsupp = The efficiency of the supplemental hot water system for household water heating demand not met by the solar hot water system.

### Baseline Efficiency:

$$WHkwh\_base = (365 \text{ days/year}) * (0.000293071 \text{ kWh/BTU}) * (V) * (\rho) * (Cp) * (\Delta T) / UEF$$

Where

V = Volume of hot water drawn based on draw pattern (Gallon), where V = 10 for the very-small-usage draw pattern, V = 38 for the low-usage draw pattern, V = 55 for the medium-usage draw pattern, V = 84 for high-usage draw pattern

$\rho$  = Water density (lb/gallon) = 8.24

Cp = Specific heat of water (Btu/lb) = 1

$\Delta T$  = Difference between inlet and outlet temp ( $\Delta T$ ) = 67

UEF = Uniform Energy Factor (see table below)

Electric Storage Water Heater Conservation Standards<sup>1</sup>

Where:

V<sub>r</sub> = Rated Storage Volume (Gallon)

| Rated Storage Volume | Draw Pattern | Uniform Energy Factor |
|----------------------|--------------|-----------------------|
| <20                  | Very Small   | 0.7836 - (0.0013 xVr) |
|                      | Low          | 0.8939 - (0.0008 xVr) |
|                      | Medium       | 0.9112 - (0.0007 xVr) |
|                      | High         | 0.9255 - (0.0006 xVr) |
| ≥20 and ≤55          | Very Small   | 0.8808 - (0.0008 xVr) |
|                      | Low          | 0.9254 - (0.0003 xVr) |
|                      | Medium       | 0.9307 - (0.0002 xVr) |
|                      | High         | 0.9349 - (0.0001 xVr) |
| >55 and ≤120         | Very Small   | 1.9236 - (0.0011 xVr) |
|                      | Low          | 2.0440 - (0.0011 xVr) |
|                      | Medium       | 2.1171 - (0.0011 xVr) |
|                      | High         | 2.2418 - (0.0011 xVr) |
| >120                 | Very Small   | 0.6802 - (0.0003 xVr) |
|                      | Low          | 0.8620 - (0.0006 xVr) |
|                      | Medium       | 0.9042 - (0.0007 xVr) |
|                      | High         | 0.9437 - (0.0007 xVr) |

**High Efficiency:**

The new system is a solar hot water heater paired with a supplemental electric water heating source.

**Measure Life:**

The measure life for a new solar hot water system is 20 years.<sup>2</sup>

| Measure Name    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|-----|
| Solar Hot Water | RES_RETAIL      | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Solar Hot Water | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% until an evaluation occurs.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are based on evaluation results.<sup>4</sup>

| Measure Name    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------|-----------------|-----|------|-----------------|------------------|------|
| Solar Hot Water | RES_RETAIL      | All | 0.30 | 0.12            | 0.00             | 0.82 |

**Non-Energy Impacts:**

There are no non-energy impacts identified with this measure.

**Endnotes:**

- 1 : <https://www.federalregister.gov/documents/2020/05/21/2020-10564/energy-conservation-program-energy-conservation-standards-for-consumer-water-heaters>
- 2 : [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 4 : [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.53. Hot Water - Stand Alone Water Heater

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-SASWH  |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

Stand-alone storage water heaters are high efficiency water heaters that are not combined with space heating devices.

### BCR Measure IDs:

| Core Initiative                                       | Measure Name                    | BCR Measure ID |
|-------------------------------------------------------|---------------------------------|----------------|
| Water Heater, Gas Storage Water Heater (<=55 Gallons) | Residential Retail (RES_RETAIL) | GA2c026        |

### Algorithms for Calculating Primary Energy Impact:

Savings are deemed and have been adjusted to reflect the mix of replace on failure and early replacement based on evaluation results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                                | Core Initiative    | Δ kWh | Δ kW  | Δ MMBtu |
|---------------------------------------------|--------------------|-------|-------|---------|
| Water Heater, Stand Alone Water Heater, Gas | RES_CD, RES_RETAIL | -43.0 | -0.01 | 2.5     |

### Baseline Efficiency:

The baseline efficiency case is a standalone tank water heater with an UEF of 0.63<sup>3</sup>. For the early retirement portion, the baseline efficiency is an existing 0.58<sup>4</sup> UEF standalone water heater.

### High Efficiency:

The high efficiency case is a stand-alone storage water heater with an energy factor  $\geq 0.66^4$ .

### Measure Life:

The measure life is assumed to be 9 years.<sup>5</sup>

| PA  | Measure Name                                | Core Initiative    | EUL | OYF | RUL | AML |
|-----|---------------------------------------------|--------------------|-----|-----|-----|-----|
| All | Water Heater, Stand Alone Water Heater, Gas | RES_CD, RES_RETAIL | 10  | n/a | n/a | 9   |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| PA  | Measure Name                                   | Core Initiative       | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----|------------------------------------------------|-----------------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| All | Water Heater, Stand Alone<br>Water Heater, Gas | RES_CD,<br>RES_RETAIL | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

### In-Service Rates

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates

Realization rates are set to 100% for deemed measures.

### Coincidence Factors

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

### Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.<sup>7</sup>

| PA  | Measure Name                                   | Core Initiative | FR   | SOP  | SONP | NTG  |
|-----|------------------------------------------------|-----------------|------|------|------|------|
| All | Water Heater, Stand Alone<br>Water Heater, Gas | RES_RETAIL      | 0.36 | 0.12 | 0.00 | 0.76 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| PA  | Measure Name                                   | Core Initiative | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----|------------------------------------------------|-----------------|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| All | Water Heater, Stand Alone<br>Water Heater, Gas | RES_RETAIL      | 1.30               | 0.00                 | 0.00              | 0.00                | 0.00                | 0.00                  |

### Endnotes:

- 1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : This is the weighted average baseline UEF of the medium and high draw units based in 2016-2017 rebated units.
- 4 : This is the weighted average baseline UEF of the medium and high draw units based in 2016-2017 rebated units. Source for updated baseline can be found here - [2021 Guidehouse TRM Final Report](#)
- 4 : This is the weighted average efficient UEF of the medium and high draw units based in 2016-2017 rebated

units.

**5** : DOE (2008). Energy Star Residential Water Heaters: Final Criteria Analysis and The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing. The calculation of the adjustment can be found in MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. [MA PAs 2020 Annual Report Gas HVAC WH Calculations GH 2021-03-08](#)

**6** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**7** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)

## 1.54. Hot Water - Thermostatic Valve

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-WH-TV     |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

### Measure Description:

A stand-alone valve that may be used with existing showerhead. Thermostatic shut-off valve technology is known by the trademarked name ShowerStart™.

### BCR Measure IDs:

| Measure Name                                      | Core Initiative                           | BCR Measure ID |
|---------------------------------------------------|-------------------------------------------|----------------|
| Thermostatic Shut-off Valve, Electric (High Rise) | Residential Coordinated Delivery (RES_CD) | EA2a227        |
| Thermostatic Shut-off Valve, Oil (High Rise)      | Residential Coordinated Delivery (RES_CD) | EA2a228        |
| Thermostatic Shut-off Valve, Other (High Rise)    | Residential Coordinated Delivery (RES_CD) | EA2a229        |
| Thermostatic Shutoff Valve, Elec                  | Residential Retail (RES_RETAIL)           | EA2c082        |
| Thermostatic Shutoff Valve, Gas                   | Residential Retail (RES_RETAIL)           | EA2c083        |
| Thermostatic Shutoff Valve, Oil                   | Residential Retail (RES_RETAIL)           | EA2c084        |
| Thermostatic Shutoff Valve, Other                 | Residential Retail (RES_RETAIL)           | EA2c085        |
| Thermostatic Shut-off Valve, Gas (High Rise)      | Residential Coordinated Delivery (RES_CD) | GA2a089        |
| Thermostatic Shut-off Valve, Gas                  | Residential Retail (RES_RETAIL)           | GA2c033        |

### Algorithms for Calculating Primary Energy Impact:

The unit savings are deemed based on engineering analysis.<sup>1</sup>

| Measure Name                                      | $\Delta kWh$ | $\Delta kW^2$ | $\Delta MMBtu$ |
|---------------------------------------------------|--------------|---------------|----------------|
| Thermostatic Shut-off Valve, Electric (High Rise) | 69           | 0.02          |                |
| Thermostatic Shut-off Valve, Gas (High Rise)      |              |               | 0.34           |
| Thermostatic Shut-off Valve, Oil (High Rise)      |              |               | 0.39           |
| Thermostatic Shut-off Valve, Other (High Rise)    |              |               | 0.34           |
| Thermostatic Shutoff Valve, Elec                  | 76           | 0.02          |                |



|                                   |  |  |      |
|-----------------------------------|--|--|------|
| Thermostatic Shutoff Valve, Gas   |  |  | 0.38 |
| Thermostatic Shutoff Valve, Oil   |  |  | 0.43 |
| Thermostatic Shutoff Valve, Other |  |  | 0.38 |

**Baseline Efficiency:**

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

**High Efficiency:**

The high efficiency case is a standard-flow showerhead (2.5 GPM) with the addition of the stand-alone thermostatic shut-off valve (the “Ladybug”).

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|-----------------------------|----------------------|-----|-----|-----|-----|-----|
| Thermostatic Shut-off Valve | RES_CD<br>RES_RETAIL | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

In Res Retail the water savings are 621 gallons per unit. In RCD the water savings are 558 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Thermostatic Shut-off Valve, Electric | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.81             |
| Thermostatic Shut-off Valve, Gas      | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Oil      | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Other    | RES_CD          | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Elec     | RES_RETAIL      | All | 0.78 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.81             |
| Thermostatic Shut-off Valve, Gas      | RES_RETAIL      | All | 0.78 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Oil      | RES_RETAIL      | All | 0.78 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Other    | RES_RETAIL      | All | 0.78 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

In RCD all installations have 100% in service rate. Res Retail in service rate is based on evaluation results.<sup>5</sup>

**Realization Rates:**

Realization rates are set to 100% since savings are deemed.

**Coincidence Factors:**

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for High Rise based on evaluation results.<sup>7 8</sup>

| Measure Name                            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Thermostatic Shut-off Valve (High Rise) | RES_CD          | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Thermostatic Shutoff Valve              | RES_RETAIL      | All | 0.03 | 0.00            | 0.00             | 0.97 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 1** : National Grid (2014). Review of ShowerStart evolve. [National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 2** : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 3** : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 4** : National Grid (2014). Review of ShowerStart evolve. [National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 5** : NMR Group Inc. (2021). Residential Products In Service Rates Memo. [2021 NMR Products ISR](#)
- 6** : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 7** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse Res NTG Final Results Memo](#)
- 8** : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

## 1.55. Lighting - LED Fixture

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-L-F     |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Lighting    |

### Measure Description:

Replacement of existing inefficient fixtures with the installation of new efficient fixtures.

### BCR Measure IDs:

| Measure                                                | Core Initiative                           | BCR Measure ID |
|--------------------------------------------------------|-------------------------------------------|----------------|
| LED Fixture, Common Area (Attached Low Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a160        |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a161        |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a162        |
| LED Fixture, Indoor Common Area (High Rise)            | Residential Coordinated Delivery (RES_CD) | EA2a244        |
| LED Fixture, Linear Indoor Common Area (High Rise)     | Residential Coordinated Delivery (RES_CD) | EA2a245        |
| LED Fixture, Outdoor Common Area (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a246        |

### Algorithms for Calculating Primary Energy Impact:

Vendor calculated unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \text{Hours}_{\text{PRE}} * ((\text{QTY}_{\text{PRE}} \times \text{Watt}_{\text{PRE}}) - (\text{QTY}_{\text{EE}} \times \text{Watt}_{\text{SEE}})) / 1000$$

$$\Delta kW = \Delta kWh \times kW/kWh$$

Where:

$\text{QTY}_{\text{PRE}}$  = Quantity of pre-retrofit fixtures/bulbs

$\text{QTY}_{\text{EE}}$  = Quantity of efficient fixtures/bulbs installed

$\text{Watt}_{\text{PRE}}$  = Rated watts of pre-retrofit fixtures/bulbs

$\text{Watt}_{\text{SEE}}$  = Rated watts of efficient fixtures/bulbs installed

$\text{Hours}_{\text{PRE}}$  = Annual hours of operation for pre-retrofit case lighting fixtures. Note that any reduction in hours of operation due to the addition of lighting controls are calculated separately; refer to that TRM entry.

$kW/kWh$  = Average kW reduction per kWh reduction: 0.00030 kW/kWh<sup>1</sup>

Annual hours of use for Residential Coordinated Delivery are based on evaluation results.<sup>2 3 4</sup> Annual hours of use for Income Eligible in-unit fixtures are deemed based on the space type -- see table below.<sup>5</sup> Annual hours of use for Income Eligible common area fixtures are determined on a site-by-site basis by the vendor.

| Measure Name                                           | Core Initiative | Δ Watts     | HOU  | # of Bulbs  | ΔKWh        | ΔkW        |
|--------------------------------------------------------|-----------------|-------------|------|-------------|-------------|------------|
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Indoor Common Area (High Rise)            | RES_CD          | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Linear Indoor Common Area (High Rise)     | RES_CD          | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Outdoor Common Area (High Rise)           | RES_CD          | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |

| In-Unit Space Type | Annual Hours of Use (HOU) |
|--------------------|---------------------------|
| Bedroom            | 730                       |
| Bathroom           | 657                       |
| Kitchen            | 1,460                     |
| Living Space       | 1,205                     |
| Dining Room        | 986                       |
| Exterior           | 2,008                     |
| Other              | 621                       |

### Baseline Efficiency:

The baseline efficiency case for Residential Coordinated Delivery and Income Eligible Coordinated Delivery is the existing fixture on site, as identified by the vendor.

### High Efficiency:

The high efficiency case is an ENERGY STAR ® rated LED fixture.

**Measure Life:**

The tables below include the EUL and AML for LED Fixtures.<sup>9</sup>

| Measure Name                                                                                                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------------------------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| LED Fixture, Indoor In Unit (Multifamily)                                                                   | RES_CD          | All | 20  | n/a | n/a | 5   |
| LED Fixture, Common Area (Attached Low Rise);<br>LED Fixture, Indoor Common Area (High Rise)                | RES_CD          | All | 6   | n/a | n/a | 6   |
| LED Fixture, Common Area, Linear (Attached Low Rise);<br>LED Fixture, Linear Indoor Common Area (High Rise) | RES_CD          | All | 8   | n/a | n/a | 8   |
| LED Fixture, Common Area, Exterior (Attached Low Rise);<br>LED Fixture, Outdoor Common Area (High Rise)     | RES_CD          | All | 11  | n/a | n/a | 11  |

**Other Resource Impacts:**

There are no other resource impacts. Interactive effects for direct install lighting are assumed to be captured in the realization rates for insulation measures within the same program.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |
| LED Fixture, Indoor Common Area (High Rise)            | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.34             | 0.30             |
| LED Fixture, Linear Indoor Common Area (High Rise)     | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.34             | 0.30             |
| LED Fixture, Outdoor Common Area (High Rise)           | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.20             |

**In-Service Rate:**

Residential Coordinated Delivery high rise LED fixture ISRs are from the Navigant evaluation report.<sup>11</sup>

**Realization Rates:**

The realization rate for Multifamily Common Area lighting in Income Eligible Coordinated Delivery are PA specific and come from the 2015 Cadmus Low-Income Multifamily evaluation report.<sup>12</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>13</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for Residential Coordinated Delivery high rise and common area LED Fixtures are from the Navigant Multi-Family evaluation.<sup>16</sup>

| Measure Name                                           | Core Initiative | PA  | FR | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------------------|-----------------|-----|----|-----------------|------------------|------|
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | All |    |                 |                  | 0.86 |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | All |    |                 |                  | 0.86 |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | All |    |                 |                  | 0.86 |
| LED Fixture, Indoor Common Area (High Rise)            | RES_CD          | All |    |                 |                  | 0.86 |
| LED Fixture, Linear Indoor Common Area (High Rise)     | RES_CD          | All |    |                 |                  | 0.86 |
| LED Fixture, Outdoor Common Area (High Rise)           | RES_CD          | All |    |                 |                  | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | All | \$91.00            |                      | \$0.03            |                     |                     |                       |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | All |                    |                      | \$0.03            |                     |                     |                       |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | All |                    |                      | \$0.03            |                     |                     |                       |
| LED Fixture, Indoor Common Area (High Rise)            | RES_CD          | All | \$91.00            |                      | \$0.03            |                     |                     |                       |

|                                                    |        |     |         |  |        |  |  |  |
|----------------------------------------------------|--------|-----|---------|--|--------|--|--|--|
| LED Fixture, Linear Indoor Common Area (High Rise) | RES_CD | All | \$91.00 |  | \$0.03 |  |  |  |
| LED Fixture, Outdoor Common Area (High Rise)       | RES_CD | All | \$91.00 |  | \$0.03 |  |  |  |

**Endnotes:**

- 1** : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 2** : NMR Group, Inc. (2018). 2019-2021 Planning Assumptions: Lighting Hours-of-Use and In-Service Rate. [2018 NMR LTGHOUSR](#)
- 3** : NMR Group, Inc. (2014). Northeast Residential Hours of Use Study. [NMR 2014 Northeast Residential Lighting HOU](#)
- 4** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 5** : NMR Group, Inc. (2020). Residential Lighting Hours-of-Use Quick Hit Study (MA20R21-E). [2019 NMR LightingHOU Update](#)
- 9** : MA PAs (2018). 2019-2021 Lighting Worksheet. [MA PAs Lighting Worksheet PY2019-2021](#)
- 11** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 12** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 13** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 16** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)

## 1.56. Lighting - Occupancy Sensors

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-L-OS    |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Lighting    |

### Measure Description:

The installation of occupancy sensors for lighting fixtures. This measure involves installing an occupancy sensor that controls lighting fixtures and limits their use when the space is unoccupied.

### BCR Measure IDs:

| Measure Name                                        | Core Initiative                           | BCR Measure ID |
|-----------------------------------------------------|-------------------------------------------|----------------|
| Occupancy Sensor, Common Area (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a163        |
| Occupancy Sensor, Common Area (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a247        |
| Occupancy Sensor, Common Area (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a098        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are based on one of the following algorithms, as appropriate to the situation.

For on/off sensors, savings are as follows:

$$\Delta kWh = (\text{WattsControlled} * \text{Hours} * \text{SVG}) / 1000$$

Where:

Watts controlled = Connected load wattage controlled by Sensor

Hours = Run time of fixture before the installation of sensors

Svg = Percentage by which hours of operation are reduced due to the sensor; site specific

For high/low sensors, savings are as follows:

$$\Delta kWh = ((\text{HighWatts} - \text{LowWatts}) * \text{Hours}) / 1000$$

Where:

HighWatts = Full load of fixture

LowWatts = Wattage of fixture when no occupancy is detected; input by auditor, typically 50% of HighWatts

Hours = Run time of fixture (24 hours, fixtures are always on)



**Baseline Efficiency:**

The baseline condition for this measure is a lighting fixture that is not controlled by an occupancy sensor.

**High Efficiency:**

The high efficiency case is a lighting fixture that operates with connected occupancy sensors.

**Measure Life:**

The measure life is 10 years.

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Occupancy Sensor, Common Area | All             | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.13             |

**In-Service Rates:**

In-service rates are set to 100% based on the assumption that all purchased units are installed.

**Realization Rates:**

Realization rates are set to 100%.

**Coincidence Factors:**

Coincidence factors come from the Demand Impact Model.<sup>1</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for Residential Coordinated Delivery are from the Guidehouse NTG evaluation.

| Measure Name                                        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Occupancy Sensor, Common Area (Attached Low Rise)   | RES_CD          |     |      |                 |                  |      |
| Occupancy Sensor, Common Area (High Rise)           | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| Occupancy Sensor, Common Area (Residential End Use) | CI_RETRO        |     |      |                 |                  |      |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Occupancy Sensor, Common Area | RES_CD          | All |                    |                      |                   |                     |                     |                       |

**Endnotes:**

1 : Navigant Consulting (2018). Demand Impact Model Update.  
[2018 Navigant Baseline Loadshape Comprehensive Report](#)

## 1.57. Lighting - Residential

|                     |                                              |
|---------------------|----------------------------------------------|
| <b>Measure Code</b> | RES-L-LEDB                                   |
| <b>Market</b>       | Residential                                  |
| <b>Program Type</b> | Lost Opportunity, New Construction, Retrofit |
| <b>Category</b>     | Lighting                                     |

### Measure Description:

The installation of Light-Emitting Diode (LED) bulbs and fixtures. LEDs offer comparable luminosity to incandescent and halogen bulbs at significantly less wattage and significantly longer lamp lifetimes.

### BCR Measure IDs:

| Measure Name                                           | Core Initiative                           | BCR Measure ID |
|--------------------------------------------------------|-------------------------------------------|----------------|
| LED Bulb, Common Area, Other (Attached Low Rise)       | Residential Coordinated Delivery (RES_CD) | EA2a159        |
| LED Bulb, Common Area (High Rise)                      | Residential Coordinated Delivery (RES_CD) | EA2a243        |
| LED Bulb, Common Area (Residential End Use)            | C&I Existing Building Retrofit (CI_RETRO) | EC2a094        |
| LED Fixture, Common Area (Attached Low Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a160        |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | Residential Coordinated Delivery (RES_CD) | EA2a161        |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | Residential Coordinated Delivery (RES_CD) | EA2a162        |
| LED Fixture, Indoor Common Area (High Rise)            | Residential Coordinated Delivery (RES_CD) | EA2a244        |
| LED Fixture, Linear Indoor Common Area (High Rise)     | Residential Coordinated Delivery (RES_CD) | EA2a245        |
| LED Fixture, Outdoor Common Area (High Rise)           | Residential Coordinated Delivery (RES_CD) | EA2a246        |

## Algorithms for Calculating Primary Energy Impact:

### Factors for Calculating Savings for Residential Lighting

Delta watts<sup>1</sup> and hours of use<sup>2,3</sup> noted in the table below for deemed measures are based on evaluation results. For vendor-calculated measures, delta watts are based on verification of pre-installation wattage, and hours of use are input by the vendor based on space type. For common area measures in multifamily buildings (labeled Attached Low Rise, High Rise, and Residential End Use), vendors reference the hours recommended in the Navigant Multifamily Impact Study<sup>4</sup>(see table below). For Income Eligible In-Unit Fixtures, vendors reference the 2014 Northeast HOU Study (see table below).<sup>5</sup> For Income Eligible common area measures, vendors calculate the hours based on site conditions.

Savings are then calculated per the algorithm below.

$$\Delta \text{kWh} = ((\text{QTY}_{\text{PRE}} \times \text{Watts}_{\text{PRE}}) - (\text{QTY}_{\text{EE}} \times \text{Watts}_{\text{EE}}) \times \text{Hours}) / 1000$$

$$\Delta \text{kW} = \Delta \text{kWh} \times \text{kW/kWh}$$

Where:

QTY<sub>PRE</sub> = Quantity of pre-retrofit fixtures/bulbs

QTY<sub>EE</sub> = Quantity of efficient fixtures/bulbs installed

Watts<sub>PRE</sub> = Rated watts of pre-retrofit fixtures/bulbs

Watts<sub>EE</sub> = Rated watts of efficient fixtures/bulbs installed

Hours = Annual hours of operation for pre-retrofit case. Note that any reduction in hours of operation due to the addition of lighting controls are calculated separately; refer to the relevant TRM entry.

kW/kWh = Average kW reduction per kWh reduction: 0.00025 kW/kWh<sup>6</sup>

| Measure Name                                           | Core Initiative | Δ Watts      | Annual HOU           | # of Bulbs  | ΔKWh              | ΔkW        |
|--------------------------------------------------------|-----------------|--------------|----------------------|-------------|-------------------|------------|
| LED Bulb, Common Area (Attached Low Rise)              | RES_CD          | Vendor Input | Varies by Space Type | N/A         | Vendor Calculated | Calculated |
| LED Bulb, Common Area (High Rise)                      | RES_CD          | Vendor Input | Varies by Space Type | N/A         | Vendor Calculated | Calculated |
| LED Bulb, Common Area (Residential End Use)            | CI_RETRO        | Vendor Input | Varies by Space Type | N/A         | Vendor Calculated | Calculated |
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | Vendor Calc  | 6388                 | Vendor Calc | Vendor Calc       | Calculated |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | Vendor Calc  | 6388                 | Vendor Calc | Vendor Calc       | Calculated |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | Vendor Calc  | 6388                 | Vendor Calc | Vendor Calc       | Calculated |
| LED Fixture, Indoor Common Area (High Rise)            | RES_CD          | Vendor Calc  | 6388                 | Vendor Calc | Vendor Calc       | Calculated |
| LED Fixture, Linear Indoor Common Area (High Rise)     | RES_CD          | Vendor Calc  | 6388                 | Vendor Calc | Vendor Calc       | Calculated |

|                                              |        |             |      |             |             |            |
|----------------------------------------------|--------|-------------|------|-------------|-------------|------------|
| LED Fixture, Outdoor Common Area (High Rise) | RES_CD | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
|----------------------------------------------|--------|-------------|------|-------------|-------------|------------|

### **Income-Eligible In-Unit Fixture HOU**

| Space Type   | Annual HOU |
|--------------|------------|
| Bedroom      | 730        |
| Bathroom     | 657        |
| Kitchen      | 1,460      |
| Living Space | 1,205      |
| Dining Room  | 986        |
| Exterior     | 2,008      |
| Other        | 621        |

### **Baseline Efficiency:**

The baseline efficiency case for Income Eligible Coordinated Delivery in-unit bulbs is a combination of an incandescent bulb and halogen bulb. The baseline efficiency case for In-Unit Fixtures and all Common Area bulbs and fixtures is the existing site conditions, as identified by the vendor.

### **High Efficiency:**

The high efficiency case is an LED.

### **Measure Life:**

The table below includes the Expected Useful Life (amount of time the LED is physically expected to last) and Adjusted Measure Life (the amount of time that the PAs claim savings). EULs for bulbs are based on a rated lifetime of 15,000 hours, per ENERGY STAR specifications. EULs for Common Area Fixtures are based on the following rated lives: Indoor - 55,000 hours; Linear - 75,000 hours; Exterior - 50,000 hours. AMLs for in-unit bulbs were derived via a consensus process with DOER. AMLs for Common Area lighting utilize.

| Measure Name                                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| LED Bulb, Common Area (Attached Low Rise)   | RES_CD          |     |     |     |     |     |
| LED Bulb, Common Area (High Rise)           | RES_CD          | All | 3   | n/a | n/a | 1   |
| LED Bulb, Common Area (Residential End Use) | CI_RETRO        |     |     |     |     |     |

|                                                                                                             |        |     |    |     |     |    |
|-------------------------------------------------------------------------------------------------------------|--------|-----|----|-----|-----|----|
| LED Fixture, Indoor In Unit (Multifamily)                                                                   | RES_CD | All | 20 | n/a | n/a | 5  |
| LED Fixture, Common Area (Attached Low Rise);<br>LED Fixture, Indoor Common Area (High Rise)                | RES_CD | All | 6  | n/a | n/a | 6  |
| LED Fixture, Common Area, Linear (Attached Low Rise);<br>LED Fixture, Linear Indoor Common Area (High Rise) | RES_CD | All | 8  | n/a | n/a | 8  |
| LED Fixture, Common Area, Exterior (Attached Low Rise);<br>LED Fixture, Outdoor Common Area (High Rise);    | RES_CD | All | 11 | n/a | n/a | 11 |

### Other Resource Impacts:

There are no other resource impacts. Interactive effects for direct install lighting are assumed to be captured in the realization rates for insulation measures within the same program.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| LED Bulb, Common Area, (Attached Low Rise)             | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.80             | 0.61             |
| LED Bulb, Common Area (High Rise)                      | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.80             | 0.61             |
| LED Bulb, Common Area (Residential End Use)            | CL_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.80             | 0.61             |
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |

|                                                    |        |     |      |      |      |      |      |      |      |
|----------------------------------------------------|--------|-----|------|------|------|------|------|------|------|
| LED Fixture, Indoor Common Area (High Rise)        | RES_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.34 | 0.30 |
| LED Fixture, Linear Indoor Common Area (High Rise) | RES_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.34 | 0.30 |
| LED Fixture, Outdoor Common Area (High Rise)       | RES_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.19 | 0.20 |

**In-Service Rate:**

Residential Coordinated Delivery high rise ISRs are based on evaluation.<sup>9</sup> All other Direct Install ISRs are assumed to be 100%.

**Realization Rates:**

Realization rates for Multifamily Common Area Lighting in Income Eligible Coordinated Delivery are PA specific and based on evaluation.<sup>10</sup>

Realization rates for Income Eligible In-Unit lighting and non-income-eligible Common Area lighting are also 100% as vendors are using deemed HOU by space type.<sup>11</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for Residential Coordinated Delivery are from the "Massachusetts Residential Programs Net-to-Gross Research of RCD and Select Products Measures" evaluation.<sup>16</sup>

| Measure Name                                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| LED Bulb, Common Area (Attached Low Rise)              | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Bulb, Common Area (High Rise)                      | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Bulb, Common Area (Residential End Use)            | CI_RETRO        |     |      |                 |                  |      |
| LED Fixture, Common Area (Attached Low Rise)           | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Fixture, Common Area, Linear (Attached Low Rise)   | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Fixture, Common Area, Exterior (Attached Low Rise) | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Fixture, Indoor Common Area (High Rise)            | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Fixture, Linear Indoor Common Area (High Rise)     | RES_CD          | All | 0.14 |                 |                  | 0.86 |
| LED Fixture, Outdoor Common Area (High Rise)           | RES_CD          | All | 0.14 |                 |                  | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name | Core Initiative | PA | Annual \$ per Unit | One-time \$ | Annual \$ per kWh | One-time \$ | Annual \$ per Therm | One-time \$ |
|--------------|-----------------|----|--------------------|-------------|-------------------|-------------|---------------------|-------------|
|              |                 |    |                    |             |                   |             |                     |             |

|                                                                 |          |     |                                                                                                                   | per<br>Unit |         | per<br>KWh |  | per<br>Therm |
|-----------------------------------------------------------------|----------|-----|-------------------------------------------------------------------------------------------------------------------|-------------|---------|------------|--|--------------|
| LED Bulb,<br>Common Area<br>(Attached Low<br>Rise)              | RES_CD   | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |
| LED Bulb,<br>Common Area<br>(High Rise)                         | RES_CD   | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |
| LED Bulb,<br>Common Area<br>(Residential End<br>Use)            | CI_RETRO | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |
| LED Fixture,<br>Common Area<br>(Attached Low<br>Rise)           | RES_CD   | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |
| LED Fixture,<br>Common Area,<br>Linear (Attached<br>Low Rise)   | RES_CD   | All |                                                                                                                   |             | \$0.027 |            |  |              |
| LED Fixture,<br>Common Area,<br>Exterior (Attached<br>Low Rise) | RES_CD   | All |                                                                                                                   |             | \$0.027 |            |  |              |
| LED Fixture,<br>Indoor Common<br>Area (High Rise)               | RES_CD   | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |
| LED Fixture,<br>Linear Indoor<br>Common Area<br>(High Rise)     | RES_CD   | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |
| LED Fixture,<br>Outdoor Common<br>Area (High Rise)              | RES_CD   | All | \$26/Unit. Values are<br>applied per fixture in the<br>BC model, and adjusted for<br>the number of fixtures/unit. |             | \$0.027 |            |  |              |

**Endnotes:**

1 : NMR Group, Inc. (2020). Delta Watt Update (MA19R09-E). [2019 NMR DeltaWattReport](#)

2 : NMR Group, Inc. (2020). Residential Lighting Hours-of-Use Quick Hit Study (MA20R21-E).  
[2019 NMR LightingHOU Update](#)



- 3** : Navigant (2017). Multifamily Program Improvement Strategies (RES42).  
[Navigant 2017 MF Program Improvement Strategies Premil Results](#)
- 4** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.  
[2018 Navigant Multifamily Program Impact Evaluation](#)
- 5** : NMR Group, Inc. (2014). Northeast Residential Hours of Use Study. [NMR 2014 Northeast Residential Lighting HOU](#)
- 6** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 9** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.  
[2018 Navigant Multifamily Program Impact Evaluation](#)
- 10** : Cadmus (2015). Low Income Multifamily Impact Evaluation.  
[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 11** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.  
[2018 Navigant Multifamily Program Impact Evaluation](#)
- 16** : Guidehouse (2021). Massachusetts Residential Programs Net-to-Gross Research of RCD and Select Products Measures. [2021 Guidehouse MA Res NTG Final Report](#)

## 1.58. Motor - Pool Pump

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | RES-MAD-PP        |
| <b>Market</b>       | Residential       |
| <b>Program Type</b> | Retrofit          |
| <b>Category</b>     | Motors and Drives |

### Measure Description:

The installation of an Energy Star rated pool pump.

### BCR Measure IDs:

| Measure Name            | Core Initiative                 | BCR Measure ID |
|-------------------------|---------------------------------|----------------|
| Pool Pump (Energy Star) | Residential Retail (RES_RETAIL) | EA2c071        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions<sup>1</sup> :

$$\Delta kWh = UEC_{baseline} - UEC_{efficient}$$

$$UEC_{annual} = UEC_{day} * days$$

$$UEC_{day} = (hours_{low} * P_{low} + hours_{high} * P_{high}) / 1000$$

Where:

$UEC_{baseline}$  = Unit Energy Consumption per year for the baseline condition (kWh)

$UEC_{efficient}$  = Unit Energy Consumption per year for the efficient condition (kWh)

UEC = Unit Energy Consumption per year (kWh)

days = Annual days of operation, 122 days

$P_{high}$  = Input power at high speed (W)

$hours_{high}$  = Daily operating hours at high speed

$P_{low}$  = Input power at low speed (W)

$hours_{low}$  = Daily operating hours at low speed

1,000 = 1,000 Watt-hours per kWh

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name | $\Delta kWh$ | $\Delta kW$ |
|--------------|--------------|-------------|
| Pool Pump    | 151          | 0.16        |

**Baseline Efficiency:**

The baseline efficiency case is pump that meets the July 2021 federal standard.<sup>3</sup>

**High Efficiency:**

The high efficiency case is an Energy Star rated pump.

**Measure Life:**

The measure life is 6 years.<sup>4</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Pool pump    | RES_RETAIL      | All | 6   | n/a | n/a | 6   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pool Pump    | RES_RETAIL      | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.55             | 0.05             |

**In-Service Rates:**

In-service rates are set to 100% based on the assumption that all purchased units are installed.

**Realization Rates:**

Realization rates are set to 100% as savings are deemed.

**Coincidence Factor:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-gross factors are based on evaluation study results.<sup>6</sup>

**2022**

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Pool Pump    | RES_RETAIL      | All | 0.11 | 0.00            | 0.00             | 0.89 |

**2023**

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Pool Pump    | RES_RETAIL      | All | 0.13 | 0.00            | 0.00             | 0.87 |

**2024**

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Pool Pump    | RES_RETAIL      | All | 0.16 | 0.00            | 0.00             | 0.84 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 
- 1 : Guidehouse (2021). Pool Pump Savings Calculations. [2021 Guidehouse Pool Pump Savings Estimate July2021](#)
  - 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
  - 3 : DOE Direct Final Rule Technical Support Document <https://www.regulations.gov/document/EERE-2015-BT-STD-0008-0105>
  - 4 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
  - 5 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
  - 6 : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)

## 1.59. Motor - Variable Frequency Drive

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | RES-MAD-VFD       |
| <b>Market</b>       | Residential       |
| <b>Program Type</b> | Retrofit          |
| <b>Category</b>     | Motors and Drives |

### Measure Description:

This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.

### BCR Measure IDs:

| Measure Name          | Core Initiative                           | BCR Measure ID |
|-----------------------|-------------------------------------------|----------------|
| Custom - Motors & VFD | Residential Coordinated Delivery (RES_CD) | EA2a250        |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (HP)(kWh/HP)$$

$$\Delta kW = (HP)(kW/HP_{SP})$$

### Where:

**HP** = Rated horsepower for the impacted motor.

**kWh / HP** = Annual electric energy reduction based on building and equipment type. See table below.

**kW / HP<sub>SP</sub>** = Summer demand reduction based on building and equipment type. See table below.

| Savings Factor                         | Building Type | Building Exhaust Fan | Cooling Tower Fan | Chilled Water Pump | Boiler Feed Water Pump | Hot Water Circulating Pump | MAF - Make-up Air Fan | Return Fan | Supply Fan | WS Heat Pump Circulating Loop |
|----------------------------------------|---------------|----------------------|-------------------|--------------------|------------------------|----------------------------|-----------------------|------------|------------|-------------------------------|
| Annual Energy Savings Factors (kWh/HP) | Multi-Family  | 3202                 | 889               | 1633               | 2340                   | 1548                       | 3082                  | 1788       | 2033       | 2563                          |

|                                                      |              |       |        |       |       |       |       |       |       |       |
|------------------------------------------------------|--------------|-------|--------|-------|-------|-------|-------|-------|-------|-------|
| Summer Demand Savings Factors (kW/HP <sub>SP</sub> ) | Multi-Family | 0.109 | -0.023 | 0.183 | 0.457 | 0.096 | 0.109 | 0.302 | 0.288 | 0.229 |
| Winter Demand Savings Factors (kW/HP <sub>WP</sub> ) | Multi-Family | 0.109 | -0.006 | 0.194 | 0.221 | 0.221 | 0.109 | 0.274 | 0.265 | 0.297 |

**kW / HP<sub>WP</sub>** = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

**Savings Factors for VFDs<sup>1 2</sup> (kWh/HP and kW/HP)**

**Baseline Efficiency:**

The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheat.

**High Efficiency:**

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

**Measure Life:**

The lifetime is 15 years.<sup>3</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| VFDs (High Rise) | RES_CD          | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name     | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| VFDs (High Rise) | RES_CD          | All | 1.00 | 0.86            | 1.00             | 0.86             | 0.86             | 0.24             | 0.24             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rate is based on evaluation results.<sup>4</sup>

**Coincidence Factors:**

CFs for all PAs set to 1.0 since summer and winter demand savings are based on evaluation results.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>5</sup>

| Measure Name     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|------|-----------------|------------------|------|
| VFDs (High Rise) | RES_CD          | All | 0.14 | 0.00            | 0.00             | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name    | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| VFD (High Rise) | RES_CD          | All | \$0.00             | \$0.00               | \$0.20            | \$0.00              | \$0.00              | \$0.00                |

**Endnotes:**

**1** : For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW and kWh/HP estimates derived from Cadmus (2012). Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR. [Cadmus 2014 VSD Loadshape Project](#)

**2** : For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW and kWh/HP estimates derived from Cadmus (2012). Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.

[Chan 2010 Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR](#)

**3** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

**4** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

**5** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.

[2021 Guidehouse MA Res NTG Final Report](#)

## 1.60. Other - Codes and Standards Advocacy

|                     |                                    |
|---------------------|------------------------------------|
| <b>Measure Code</b> | RES-CM-CSA                         |
| <b>Market</b>       | Residential                        |
| <b>Program Type</b> | Lost Opportunity, New Construction |
| <b>Category</b>     | Other                              |

### Measure Description:

The Mass Save Codes and Standards Advocacy program works with stakeholders to advocate for higher energy code and appliance standards. This Advocacy is on both the state and federal level.

### BCR Measure IDs:

| Measure Name                  | Core Initiative                                | BCR Measure ID |
|-------------------------------|------------------------------------------------|----------------|
| Codes Development and Support | Residential New Homes & Renovations (RES_NH&R) | EA1a020        |
| Standards Adoption            | Residential Retail (RES_RETAIL)                | EA2c343        |
| Codes Development and Support | Residential New Homes & Renovations (RES_NH&R) | GA1a017        |
| Standards Adoption            | Residential Retail (RES_RETAIL)                | GA2c079        |

### Algorithms for Calculating Primary Energy Impact:

Savings for Program Administrator activity in the Codes and Standards Advocacy initiative will be reviewed on a case by case basis. Each activity will have its own unique level of effort and its own corresponding level of savings.

Savings for the Codes Development and Support measure are outlined in the table below. There are no Electric PA residential savings for this measure. Savings are based on an evaluation study.<sup>1</sup> Savings were distributed among gas PAs based on residential customer counts.

| Savings (Therms)                |        |        |        |
|---------------------------------|--------|--------|--------|
| PA                              | 2022   | 2023   | 2024   |
| Berkshire Gas                   | 4,062  | 3,874  | 2,250  |
| Eversource Gas of Massachusetts | 34,404 | 32,816 | 19,054 |
| Eversource Gas                  | 30,623 | 29,210 | 16,960 |
| Liberty Utilities               | 6,081  | 5,800  | 3,368  |



|               |        |        |        |
|---------------|--------|--------|--------|
| National Grid | 98,695 | 94,140 | 54,662 |
| Unitil        | 1,677  | 1,600  | 929    |

**Baseline Efficiency:**

The baseline level of efficiency will also be determined on a case by case basis. The baseline level of efficiency for each avenue of advocacy would correspond to the energy code or appliance standard that would have been in place without the intervention of the Program Administrators.

**High Efficiency:**

The high efficiency case would be the energy code or appliance standard that was advocated for by the Program Administrators.

**Measure Life:**

The measure life is assumed to be 20 years but could be adjusted on a case by case basis.

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| Codes Development and Support | RES_NH&R        | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts associated with this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RRe  | RRne | RRsp | RRwp | CFsp | CFwp |
|-------------------------------|-----------------|-----|------|------|------|------|------|------|------|
| Codes Development and Support | RES_NH&R        | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | n/a  | n/a  |
| Standards Adoption            | RES_RETAIL      | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | n/a  | n/a  |

**In-Service Rates:**

All PAs use 100% in service rate.

**Realization Rates:**

All PAs use 100% realization rates.

**Coincidence Factors:**

Per Statewide agreement, kW will not be claimed for this measure.

**Impact Factors for Calculating Net Savings:**

The net-to-gross value is assumed to be 100% but will be adjusted on a case by case basis. Each activity will have its own unique level of effort and its own corresponding net-to-gross value.

| Measure Name                  | Core Initiative | PA  | FR   | SOp  | SONp | NTG  |
|-------------------------------|-----------------|-----|------|------|------|------|
| Codes Development and Support | RES_NH&R        | All | 0.00 | 0.00 | 0.00 | 1.00 |
| Standards Adoption            | RES_RETAIL      | All | 0.00 | 0.00 | 0.00 | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts associated with this measure.

**Endnotes:**

1 : NMR Group, Inc. (2020). Code Promulgation Attribution Study.  
[2020 NMR Code Promulgation Attribution Study](#)

## 1.61. Other - Small Equipment Electrification

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | RES-HVAC-ELEC    |
| <b>Market</b>       | Residential      |
| <b>Program Type</b> | Lost Opportunity |
| <b>Category</b>     | Plug Load        |

### Measure Description:

Rebates provided for the purchase of electric equipment instead of gas or propane equipment.

### BCR Measure IDs:

| Measure             | Core Initiative                 | BCR Measure ID |
|---------------------|---------------------------------|----------------|
| Electric Lawnmower  | Residential Retail (RES_RETAIL) | EA2c341        |
| Electric Leafblower | Residential Retail (RES_RETAIL) | EA2c349        |
| Electric Trimmer    | Residential Retail (RES_RETAIL) | EA2c350        |
| Electric Chainsaw   | Residential Retail (RES_RETAIL) | EA2c351        |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh savings are deemed.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name        | Core Initiative | $\Delta$ kWh | $\Delta$ kW |
|---------------------|-----------------|--------------|-------------|
| Electric Lawnmower  | RES_RETAIL      | -218         | -0.23       |
| Electric Leafblower | RES_RETAIL      | -0.78        | 0.00        |
| Electric Trimmer    | RES_RETAIL      | -0.71        | 0.00        |
| Electric Chainsaw   | RES_RETAIL      | -1.02        | 0.00        |

### Baseline Efficiency:

The baseline efficiency case for electric lawn equipment is gas powered versions of the equipment.

### High Efficiency:

The high efficiency case is electric lawn equipment.

**Measure Life:**

The measure life is shown below.<sup>3</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Electric Lawnmower  | RES_RETAIL      | All | 7   | n/a | n/a | 7   |
| Electric Leafblower | RES_RETAIL      | All | 8   | n/a | n/a | 8   |
| Electric Trimmer    | RES_RETAIL      | All | 8   | n/a | n/a | 8   |
| Electric Chainsaw   | RES_RETAIL      | All | 8   | n/a | n/a | 8   |

**Other Resource Impacts:**

| Measure Name        | Core Initiative | PA  | Gasoline (MMBTUs) <sup>4</sup> |
|---------------------|-----------------|-----|--------------------------------|
| Electric Lawnmower  | RES_RETAIL      | All | 2.5                            |
| Electric Leafblower | RES_RETAIL      | All | 1.4                            |
| Electric Trimmer    | RES_RETAIL      | All | 1.4                            |
| Electric Chainsaw   | RES_RETAIL      | All | 1.4                            |

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Electric Lawnmower  | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Leafblower | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Trimmer    | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Chainsaw   | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |

**In-Service Rates:**

The in-service rate is assumed to be 100% absent evaluation.

**Realization Rates:**

The realization rate is assumed to be 100% absent evaluation.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------|-----------------|-----|------|-----------------|------------------|------|
| Electric Lawnmower  | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Leafblower | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Trimmer    | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Chainsaw   | RES_RETAIL      | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts for this measure.

**Endnotes:**

1 : Vermont Act 56 Tier III Technical Advisory Group 2020 Annual Report

2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

3 : Vermont Act 56 Tier III Technical Advisory Group 2020 Annual Report

4 : Vermont Act 56 Tier III Technical Advisory Group 2020 Annual Report

5 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 1.62. Plug Load - Advanced Power Strip

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | RES-PL-APS  |
| <b>Market</b>       | Residential |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Plug Load   |

### Measure Description:

Advanced power strips can automatically eliminate standby power loads of electronic peripheral devices that are not needed (DVD player, computer printer, scanner, etc.) either automatically or when an electronic control device (typically a television or personal computer) is in standby or off mode.

### BCR Measure IDs:

| Measure Name        | Core Initiative                           | BCR Measure ID |
|---------------------|-------------------------------------------|----------------|
| Smart Strip, Tier 1 | Residential Coordinated Delivery (RES_CD) | EA2a008        |
| Smart Strip, Tier 2 | Residential Coordinated Delivery (RES_CD) | EA2a009        |
| Smart Strip, Tier 1 | Residential Retail (RES_RETAIL)           | EA2c073        |
| Smart Strip, Tier 2 | Residential Retail (RES_RETAIL)           | EA2c074        |
| Smart Strip, Tier 1 | Residential Coordinated Delivery (RES_CD) | GA2a116        |
| Smart Strip, Tier 2 | Residential Coordinated Delivery (RES_CD) | GA2a117        |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

### Savings for Smart Strips

| Measure Name        | Core Initiative | kWh | kW   |
|---------------------|-----------------|-----|------|
| Smart Strip, Tier 1 | All             | 105 | 0.01 |
| Smart Strip, Tier 2 | All             | 207 | 0.02 |

### Baseline Efficiency:

The baseline efficiency case is the customers' devices as they are currently operating.

**High Efficiency:**

The high efficiency case is the installation of an Advanced Power Strip.

**Measure Life:**

The measure life is assumed to be 5 years.

| Measure Name | Core Initiative    | PA  | EUL | OYF | RUL | AML |
|--------------|--------------------|-----|-----|-----|-----|-----|
| Smart Strip  | RES_CD, RES_RETAIL | All | 5   | n/a | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Smart Strip, Tier 1 | RES_CD          | All | 0.73 | 0.92            | n/a              | 0.92             | 0.92             | 1.00             | 1.00             |
| Smart Strip, Tier 2 | RES_CD          | All | 0.73 | 0.92            | 0.92             | 0.92             | 0.92             | 1.00             | 1.00             |
| Smart Strip, Tier 1 | RES_RETAIL      | All | 0.83 | 0.92            | 0.92             | 0.92             | 0.92             | 1.00             | 1.00             |
| Smart Strip, Tier 2 | RES_RETAIL      | All | 0.83 | 0.92            | 0.92             | 0.92             | 0.92             | 1.00             | 1.00             |

**In-Service Rates**

For RCD In-Service Rates are blended and based on evaluation results.<sup>3 4</sup> For Retail In-service rates are based on consumer surveys, as found in the referenced study.<sup>5</sup>

**Realization Rates**

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.<sup>6</sup>

**Coincidence Factors**

Summer and winter coincidence factors are from the referenced study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on study results.<sup>8</sup> The study produced separate values for smart strips that were mailed as part of a VHEA and those that were left behind during an in-person HEA. The values in the table below are a weighted average where it was assumed that half would be mailed and half would be left behind in 2022-2024.

| Measure             | Core Initiative | PA  | 2022 NTG | 2023 NTG | 2024 NTG |
|---------------------|-----------------|-----|----------|----------|----------|
| Smart Strip, Tier 1 | RES_CD          | All | 0.94     | 0.94     | 0.92     |
| Smart Strip, Tier 2 | RES_CD          | All | 0.94     | 0.94     | 0.92     |
| Smart Strip, Tier 1 | RES_RETAIL      | All | 0.91     | 0.90     | 0.88     |
| Smart Strip, Tier 2 | RES_RETAIL      | All | 0.91     | 0.90     | 0.88     |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 1 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. [2019 NMR APSMeteringReport Revised](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : Guidehouse (2021). Virtual Home Energy Assessment Study. [2021 Guidehouse VHEA Report FINAL](#)
- 4 : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)
- 5 : NMR Group Inc. (2021). Residential Products In Service Rates Memo. [2021 NMR Products ISR](#)
- 6 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. [2019 NMR APSMeteringReport Revised](#)
- 7 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. [2018 NMR APS Metering Report](#)
- 8 : NMR Group, Inc. (2021). Residential Products NTG Report. [2021 NMR Res Products NTG Report](#)



## 1.63. Refrigeration - Vending Miser

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | RES-R-VM      |
| <b>Market</b>       | Residential   |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

### Measure Description:

Controls can significantly reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.

### BCR Measure IDs:

| Measure Name   | Core Initiative                           | BCR Measure ID |
|----------------|-------------------------------------------|----------------|
| Vending Misers | Residential Coordinated Delivery (RES_CD) | EA2a249        |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (kW_{RATED})(Hours)(SAVE)$$

$$\Delta kW = \Delta kWh / Hours$$

Where:

$kW_{RATED}$  = Rated kW of connected equipment. See table below for default rated kW by connected equipment type.

Hours = Operating hours of the connected equipment: default of 8,760 hours

SAVE = Percent savings factor for the connected equipment. See table below for values.

### Vending Machine and Cooler Controls Savings Factors<sup>1</sup>

| Equipment Type                         | $kW_{RATED}$ | SAVE (%) | $\Delta kW$ | $\Delta kWh$ |
|----------------------------------------|--------------|----------|-------------|--------------|
| Refrigerated Beverage Vending Machines | 0.40         | 46       | 0.18        | 1612         |

### Baseline Efficiency:

The baseline efficiency case is a standard efficiency refrigerated beverage vending machine without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**High Efficiency:**

The high efficiency case is a standard efficiency refrigerated beverage vending machine with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**Measure Life:**

The measure life is 5 years.<sup>2</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Vending Misers | RES_CD          | All | 5   | n/a | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name   | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Vending Misers | RES_CD          | All | 1.00 | 0.86            | n/a              | 0.86             | 0.86             | 0.23             | 0.23             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on evaluation study results.<sup>3</sup>

**Coincidence Factors:**

CFs based on staff estimates- assumed that savings occur during off peak hours.

**Impact Factors for Calculating Net Savings:**

Net to gross factors based on evaluation results.<sup>4</sup>

| Measure Name   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------|-----------------|-----|------|-----------------|------------------|------|
| Vending Misers | RES_CD          | All | 0.14 | 0.00            | 0.00             | 0.86 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

1 : USA Technologies Energy Management Product Sheets (2006).

[USA Tech 2006 Energy Management Product Sheets](#)

2 : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

3 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

**4** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.

[2021 Guidehouse MA Res NTG Final Report](#)

## 1.64. Whole Building - Residential New Construction

|                     |                                                         |
|---------------------|---------------------------------------------------------|
| <b>Measure Code</b> | RES-BE-RNC                                              |
| <b>Market</b>       | Residential                                             |
| <b>Program Type</b> | New Construction                                        |
| <b>Category</b>     | Heating Ventilation and Air Conditioning, Water Heating |

### Measure Description:

The Residential New Construction (RNC) program and Renovations & Additions (R&A) program aim to capture lost opportunities and to drive the new homes market towards net-zero energy.

### BCR Measure IDs:

| Measure Name                      | Core Initiative                                | BCR Measure ID |
|-----------------------------------|------------------------------------------------|----------------|
| RNC Heating (Low Rise)            | Residential New Homes & Renovations (RES_NH&R) | EA1a001        |
| RNC Cooling (Low Rise)            | Residential New Homes & Renovations (RES_NH&R) | EA1a002        |
| RNC Water Heating (Low Rise)      | Residential New Homes & Renovations (RES_NH&R) | EA1a003        |
| RNC Heating (High Rise)           | Residential New Homes & Renovations (RES_NH&R) | EA1a008        |
| RNC Cooling (High Rise)           | Residential New Homes & Renovations (RES_NH&R) | EA1a009        |
| RNC Water Heating (High Rise)     | Residential New Homes & Renovations (RES_NH&R) | EA1a010        |
| RNC Lighting (High Rise)          | Residential New Homes & Renovations (RES_NH&R) | EA1a011        |
| RNC Heating (Passive House)       | Residential New Homes & Renovations (RES_NH&R) | EA1a013        |
| RNC Cooling (Passive House)       | Residential New Homes & Renovations (RES_NH&R) | EA1a014        |
| RNC Water Heating (Passive House) | Residential New Homes & Renovations (RES_NH&R) | EA1a015        |
| RNC Lighting (Passive House)      | Residential New Homes & Renovations (RES_NH&R) | EA1a016        |
| RNC Heating - All-Electric        | Residential New Homes & Renovations (RES_NH&R) | EA1a018        |
| RNC Water Heating - All-Electric  | Residential New Homes & Renovations (RES_NH&R) | EA1a019        |
| R&A Heating                       | Residential New Homes & Renovations (RES_NH&R) | EA1a005        |
| R&A Cooling                       | Residential New Homes & Renovations (RES_NH&R) | EA1a006        |
| R&A Water Heating                 | Residential New Homes & Renovations (RES_NH&R) | EA1a007        |

|                                  |                                                |         |
|----------------------------------|------------------------------------------------|---------|
| Heating (New Construction)       | Residential New Homes & Renovations (RES_NH&R) | GA1a001 |
| Cooling (New Construction)       | Residential New Homes & Renovations (RES_NH&R) | GA1a002 |
| Water Heating (New Construction) | Residential New Homes & Renovations (RES_NH&R) | GA1a003 |
| Heating (Additions)              | Residential New Homes & Renovations (RES_NH&R) | GA1a005 |
| Cooling (Additions)              | Residential New Homes & Renovations (RES_NH&R) | GA1a006 |
| Water Heating (Additions)        | Residential New Homes & Renovations (RES_NH&R) | GA1a007 |
| Heating (High Rise)              | Residential New Homes & Renovations (RES_NH&R) | GA1a008 |
| Cooling (High Rise)              | Residential New Homes & Renovations (RES_NH&R) | GA1a009 |
| Water Heating (High Rise)        | Residential New Homes & Renovations (RES_NH&R) | GA1a010 |
| Lighting (High Rise)             | Residential New Homes & Renovations (RES_NH&R) | GA1a011 |
| Heating (Passive House)          | Residential New Homes & Renovations (RES_NH&R) | GA1a013 |
| Cooling (Passive House)          | Residential New Homes & Renovations (RES_NH&R) | GA1a014 |
| Water Heating (Passive House)    | Residential New Homes & Renovations (RES_NH&R) | GA1a015 |
| Lighting (Passive House)         | Residential New Homes & Renovations (RES_NH&R) | GA1a016 |

### Algorithms for Calculating Primary Energy Impact:

Savings are derived from two modeling pathways within this initiative: the Low-Rise Performance Path, and the Multifamily High-Rise Performance Path.

The Program Administrators currently use vendor calculated energy savings for Low-Rise Performance Path projects. These savings are calculated using a RESNET accredited Rating Software Tool (Ekotrope) where a user inputs a detailed set of technical data about a project, comparing as-built projected energy consumption to that of a baseline home, the User-Defined Reference Home (UDRH). This process is used to calculate electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes, both single family and multifamily buildings (three stories and below).

For homes participating in the Multifamily High-Rise Path, the vendor models savings using a proprietary software. The software models the consumption of the as-built efficient building and compares that consumption to an architecturally similar building with baseline efficient equipment. The difference in consumption yields Heating, Cooling, Water Heating, and Lighting savings.

| Measure       | kW-per-kWh |
|---------------|------------|
| Heating       | 0.00073    |
| Cooling       | 0.00143    |
| Water Heating | 0.00025    |

|                      |         |
|----------------------|---------|
| Lighting (High Rise) | 0.00025 |
|----------------------|---------|

**Baseline Efficiency:**

The User-Defined Reference Home (UDRH) is used for low-rise projects. It was updated in early 2020.<sup>1</sup> The Multifamily High-Rise baseline is evaluated separately.<sup>2</sup> Starting in 2020, renovation project savings use an Industry Standard Practice (ISP) baseline, per the recommendation provided by NMR in the R&A Market Characterization Study.<sup>3</sup>

**High Efficiency:**

The high-efficiency case is represented by the specific energy characteristics of each “as-built” home completed through the program.

**Measure Life:**

| Measure Name         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------|-----------------|-----|-----|-----|-----|-----|
| Heating              | RES_NH&R        | All | 25  | n/a | n/a | 25  |
| Cooling              | RES_NH&R        | All | 25  | n/a | n/a | 25  |
| Water Heating        | RES_NH&R        | All | 15  | n/a | n/a | 15  |
| Lighting (High Rise) | RES_NH&R        | All | 1   | n/a | n/a | 1   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure              | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating              | RNH&R           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |
| Cooling              | RNH&R           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.50             | 0.04             |
| Water Heating        | RNH&R           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Lighting (High Rise) | RNH&R           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |

**In-Service Rates:**

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

**Realization Rates:**

Realization rates are 100% because energy and demand savings are custom-calculated based on project specific detail.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

National Grid uses custom calculated coincidence factors based on vendor-calculated project-specific detail.

### Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.<sup>5 6</sup>

| Measure Name            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------|-----------------|-----|------|-----------------|------------------|------|
| RNC Low Rise (2023)     | RNH&R           | All | 0.82 | 0.00            | 0.31             | 0.49 |
| RNC Low Rise (2023)     | RNH&R           | All | 0.82 | 0.00            | 0.25             | 0.43 |
| RNC Low Rise (2024)     | RNH&R           | All | 0.82 | 0.00            | 0.20             | 0.38 |
| RNC High Rise           | RNH&R           | All | --   | --              | --               | 0.83 |
| RNC Passive House       | RNH&R           | All | --   | --              | --               | 0.90 |
| Renovations & Additions | RNH&R           | All | 0.22 | 0.02            | 0.12             | 0.92 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.<sup>7</sup> The heating values are applied based on the home's primary heating fuel.

| Measure Name                     | Core Initiative | PA  | Annual \$ /Unit | One-time \$/Unit | Annual \$/kWh | One-time \$/KWh | Annual \$/Therm | One-time \$/Therm |
|----------------------------------|-----------------|-----|-----------------|------------------|---------------|-----------------|-----------------|-------------------|
| Heating (New Construction)       | RNH&R           | All | \$142.30        |                  |               |                 |                 |                   |
| Cooling (New Construction)       | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Water Heating (New Construction) | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Heating (Renovations)            | RNH&R           | All | \$142.30        |                  |               |                 |                 |                   |
| Cooling (Renovations)            | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Water Heating (Renovations)      | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Heating (High Rise)              | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Cooling (High Rise)              | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Water Heating (High Rise)        | RNH&R           | All |                 |                  |               |                 |                 |                   |
| Lighting (High Rise)             | RNH&R           | All |                 |                  |               |                 |                 |                   |

**Endnotes:**

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- 1** : NMR Group, Inc. (2019). 2019 Residential New Construction Baseline/Compliance Study. [2019 NMR RNC-LowRise-UDRH Baseline](#)
- 2** : NMR Group Inc. (2017). Massachusetts Multifamily High Rise Baseline Study. [NMR 2017 MA MFHR Baseline](#)
- 3** : NMR Group, Inc. (2019). Renovations and Additions Market Characterization and Potential Savings Study. [2019 NMR R&A-Market-Potential](#)
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5** : NMR Group, Inc. (2018). Residential New Construction and CCSI Attribution Assessment. [2018 NMR RNC CCSI Attribution](#)
- 6** : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report](#)



## 2. Income Eligible Efficiency Measures

### 2.1. Appliance - Dehumidifier

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-PL-ERDH      |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Plug Load       |

#### Measure Description:

Rebate for the purchase of an Energy Star dehumidifier or early retirement of an existing dehumidifier.

#### BCR Measure IDs:

| Measure Name                  | Core Initiative                              | BCR Measure ID |
|-------------------------------|----------------------------------------------|----------------|
| Early Retirement Dehumidifier | Income Eligible Coordinated Delivery (IE_CD) | EB1a121        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = \text{Dehumidification Load} * ((1/\text{EffRETIRE}) - (1/\text{EffEE}))$$

Where:

Dehumidification Load = Typical annual moisture removal, in Liters/year. Average annual dehumidification load is 1,520 Liters/year.<sup>1</sup>

EffRETIRE = Average efficiency of model being recycled, in Liters/kWh (1.6 Liters/kWh)

EffEE = Efficiency of ENERGY STAR® model, in Liters/kWh (3.3 Liters/kWh)

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                  | $\Delta kWh$ | $\Delta kW$ |
|-------------------------------|--------------|-------------|
| Early Retirement Dehumidifier | 489          | 0.11        |

#### Baseline Efficiency:

The baseline efficiency is a unit that is approximately 8 years old, meeting the standard that was in place at the time.<sup>3</sup>

**High Efficiency:**

The high efficiency case is a new ENERGY STAR® unit.<sup>4</sup>

**Measure Life:**

The measure life is 12 years.<sup>5</sup>

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| Early Retirement Dehumidifier | IE_CD           | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Early Retirement Dehumidifier | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.82             | 0.17             |

**In-Service Rates:**

In-service rates are 100% because recycled units are collected.

**Realization Rates:**

Realization rates are set to 100% as unit savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Early Retirement Dehumidifier | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

1 : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**3** : The Energy Policy Act of 2005, 42 USC §13201 et seq. Accessed at <https://www.gpo.gov/fdsys/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf>

**4** : ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Version 4.0. Accessed at

[https://www.energystar.gov/sites/default/files/ENERGY%20STAR\\_Dehumidifiers\\_V4%200\\_Specificati on\\_Final.pdf](https://www.energystar.gov/sites/default/files/ENERGY%20STAR_Dehumidifiers_V4%200_Specificati%20on_Final.pdf)

**5** : Environmental Protection Agency (2018). Savings Calculator for ENERGY STAR Qualified Appliances. [Energy Star 2018 Consumer Appliance Calc](#)

**6** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

## 2.2. Appliance - Early Retirement Clothes Washer

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-A-ERCW       |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Appliances      |

### Measure Description:

The replacement and recycling of a working top-loading clothes washer with an agitator with an Energy Star rated washing machine.

### BCR Measure IDs:

| Measure Name                                 | Core Initiative                              | BCR Measure ID |
|----------------------------------------------|----------------------------------------------|----------------|
| Early Retirement CW Elec DHW & Elec Dryer    | Income Eligible Coordinated Delivery (IE_CD) | EB1a123        |
| Early Retirement CW Gas DHW & Elec Dryer     | Income Eligible Coordinated Delivery (IE_CD) | EB1a124        |
| Early Retirement CW Elec DHW & Gas Dryer     | Income Eligible Coordinated Delivery (IE_CD) | EB1a125        |
| Early Retirement CW Gas DHW & Gas Dryer      | Income Eligible Coordinated Delivery (IE_CD) | EB1a127        |
| Early Retirement CW Oil DHW & Elec Dryer     | Income Eligible Coordinated Delivery (IE_CD) | EB1a126        |
| Early Retirement CW Propane DHW & Elec Dryer | Income Eligible Coordinated Delivery (IE_CD) | EB1a128        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:

$$\Delta kWh = [(Capacity \times 1/IMEF_{base} \times N_{cycles}) \times (\%CW_{kwhbase} + \%DHW_{kwhbase} + \%Dryer_{kwhbase})] - [(Capacity \times 1/IMEF_{eff} \times N_{cycles}) \times (\%CW_{kwh_{eff}} + \%DHW_{kwh_{eff}} + \%Dryer_{kwh_{eff}})]$$

$$\Delta MMBTUs = [(Capacity \times 1/MEF_{base} \times N_{cycles}) \times ((\%DHW_{ffbase} \times r_{eff}) + \%Dryer_{ffbase})] - [(Capacity \times 1/MEF_{eff} \times N_{cycles}) \times ((\%DHW_{ff_{eff}} \times r_{eff}) + \%Dryer_{gaseff})] \times MMBTU_{convert}$$

Where:

Capacity = washer volume in ft<sup>3</sup>. Existing top loading washer is 3.09 ft<sup>3</sup>, new standard efficiency top loading washer is 3.38 ft<sup>3</sup>, ENERGY STAR front loading is 3.90 ft<sup>3</sup>

IMEF = Integrated Modified Energy Factor and is measured in ft<sup>3</sup> /kWh/cycle

Ncycles = 283 loads per year<sup>1</sup>

%CWkwh = % of total kWh energy consumption for clothes washer operation (different for baseline and efficient unit). See table below

%DHWkwh = % of total kWh energy consumption used for water heating (different for baseline and efficient unit). See table below. If water is heated by gas or propane this is 0%

%DHWff = % of total kWh energy consumption for dryer operation (different for baseline and efficient unit). See table below. If the dryer is gas this is 0%

%Dryerkwh = % of total fossil fuel energy consumption used for water heating (different for baseline and efficient unit). See table below. If water is heated by electric this is 0%.

%Dryerff = % of total fossil fuel energy consumption for dryer operation (different for baseline and efficient unit). See table below. If the dryer is electric this is 0%.

r\_eff = recovery energy factor used to account for the difference in recovery efficiencies of electric and gas/oil/propane hot water heaters. Electric water heaters are 100% efficient while other water heaters are 75% efficient. The ratio is 1.33 (100%/75%)

MMBTU\_convert = Conversion factor from kWh to MMBTU is 0.003412

**Efficiency Ratings and Percentage of Total Energy Consumption<sup>2</sup>**

|                                     | % Energy used for: |               |        | IMEF          | IWF               | Volume |
|-------------------------------------|--------------------|---------------|--------|---------------|-------------------|--------|
|                                     | Washer operation   | Water heating | Drying | ft3/kWh/cycle | gallons/cycle/ft3 | ft3    |
| Existing-Top Loading CW             | 8%                 | 34%           | 59%    | 0.84          | 9.92              | 3.09   |
| New-Federal Standard Top Loading CW | 5%                 | 37%           | 58%    | 1.29          | 8.44              | 3.38   |
| New-Energy Star Front Loading CW    | 8%                 | 20%           | 72%    | 2.38          | 3.70              | 3.90   |

**Savings from Early Retirement of Clothes Washers**

| Measure Name                                 | ΔkWh  | ΔkW <sup>3</sup> | ΔMMBtu |
|----------------------------------------------|-------|------------------|--------|
| Early Retirement CW Elec DHW & Elec Dryer    | 600   | 0.18             | 0.00   |
| Early Retirement CW Gas DHW & Elec Dryer     | 260.5 | 0.08             | 1.54   |
| Early Retirement CW Elec DHW & Gas Dryer     | 375   | 0.11             | 0.76   |
| Early Retirement CW Oil DHW & Elec Dryer     | 260.5 | 0.08             | 1.54   |
| Early Retirement CW Gas DHW & Gas Dryer      | 35.7  | 0.01             | 2.31   |
| Early Retirement CW Propane DHW & Elec Dryer | 260.5 | 0.08             | 1.54   |

**Baseline Efficiency:**

It is assumed that the existing top loading clothes washer met the 2007 federal standard which was an MEF > 1.262 and WF < 9.53. This is equivalent to an IMEF of 0.84 and IWH of 9.92. A new standard efficiency clothes washer meets the federal standard for top loading washers effective 1/1/18 which requires an IMEF > 1.57 and an IWF < 6.5.

MEF is Modified Energy Factor and is measured in ft<sup>3</sup>/kWh/cycle  
 WF is Water Factor and is measured in gallons/cycle/ft  
 IMEF is Integrated Modified Energy Factor and is measured in ft<sup>3</sup>/kWh/cycle  
 IWF is Integrated Water Factor and is measured in gallons/cycle/ft<sup>3</sup>

**High Efficiency:**

The new high efficiency washer is an Energy Star (Version 8.0) rated front loader washer with a minimum IMEF > 2.76 and IWF < 3.2.<sup>4</sup>

**Measure Life:**

The effective useful life of the new clothes washer is assumed to be 12 years.<sup>5</sup> It is assumed that without the program, Income Eligible customers would have purchased a used clothes washer meeting the 2007 federal standards, so the savings are counted for the full lifetime of the measure.

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Early Retirement CW | IE_CD           | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

Water savings are calculated using the following algorithm:  
 $\Delta\text{Water (gallons)} = (\text{Capacity} * (\text{IWF}_{\text{base}} - \text{IWF}_{\text{eff}})) * \text{Ncycles}$   
 Total water savings are 4,777 gallons.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Early Retirement CW | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.42             | 0.56             |

**In-Service Rates:**

In-service rates are set to 100% based on the assumption that all purchased units are installed.

**Realization Rates:**

Realization rates are based on Massachusetts Common Assumptions.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

### Impact Factors for Calculating Net Savings:

Net-to-Gross values have not been studied. The default NTG is 1.00.

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------|-----------------|-----|------|-----------------|------------------|------|
| Early Retirement CW | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Early Retirement CW | IE_CD           | All |                    |                      | Varies by PA      | 0.01                |                     |                       |

### Endnotes:

- 1 : DOE (2013). 10 CFR Parts 429 and 430 Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule [DOE 2013 Test Procedures for Residential Clothes Dryers](#)
- 2 : DOE (2012). Residential Clothes Washers Direct Final Rule Technical Support Document; Chapter 7. [DOE 2012 Technical Support Document Clothes Washers](#)
- 3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 4 : New Energy Star standard as of 2/5/18
- 5 : Environmental Protection Agency (2018). Savings Calculator for ENERGY STAR Qualified Appliances. [https://www.energystar.gov/sites/default/files/asset/document/appliance\\_calculator.xlsx](https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx) [Energy Star 2018 Consumer Appliance Calc](#)
- 6 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.3. Appliance - Freezer Replacement

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-A-FR         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Appliances      |

### Measure Description:

This measure covers the replacement of an existing inefficient freezer with a new energy efficient model

### BCR Measure IDs:

| Measure                             | Core Initiative                              | BCR Measure ID |
|-------------------------------------|----------------------------------------------|----------------|
| Freezer Replacement (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a037        |
| Freezer Replacement (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a114        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                        | Core Initiative | $\Delta kWh$ | $\Delta kW$ |
|-------------------------------------|-----------------|--------------|-------------|
| Freezer Replacement (Single Family) | IE_CD           | 239          | 0.04        |
| Freezer Replacement (Multifamily)   | IE_CD           | 158          | 0.03        |

### Baseline Efficiency:

The baseline efficiency case for both the replaced and baseline new freezer is represented by the existing freezer. It is assumed that low-income customers would replace their freezers with a used inefficient unit.

### High Efficiency:

The high efficiency case is a new high efficiency freezer.



**Measure Life:**

The measure life is 12 years.<sup>3</sup>

| Measure Name                        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Freezer Replacement (Single Family) | IE_CD           | All | 12  | n/a | n/a | 12  |
| Freezer Replacement (Multifamily)   | IE_CD           | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Freezer Replacement (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.85             | 0.65             |
| Freezer Replacement (Multifamily)   | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.85             | 0.65             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Freezer Replacement (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Freezer Replacement (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

| Measure Name                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Freezer Replacement (Single Family) | IE_CD           | All | \$1.40             |                      | Varies by PA      | \$0.01              |                     |                       |
| Freezer Replacement (Multifamily)   | IE_CD           | All | \$20.29            |                      | Varies by PA      | \$0.01              |                     |                       |

**Endnotes:**

- 1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances. [Energy Star 2018 Consumer Appliance Calc](#)
- 4 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.4. Appliance - Refrigerator Replacement - IE Multi-Family

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-A-RR-MF      |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Appliances      |

### Measure Description:

Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.

### BCR Measure IDs:

| Measure Name                           | Core Initiative                              | BCR Measure ID |
|----------------------------------------|----------------------------------------------|----------------|
| Refrigerator Replacement (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a115        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = ((kWh_{pre} - kWh_{ES}) \times RUL/EUL) + ((kWh_{std} + kWh_{used}/2 - kWh_{ES}) \times EUL - RUL/EUL) \times F_{occ}$$

$$\Delta kW = \Delta kWh \times kW/kWh$$

Where:

$kWh_{pre}$  = Annual kWh consumption of existing equipment. Value is based on metering or AHAM database. The default value is 874 kWh.

$kWh_{ES}$  = Annual kWh consumption of new ENERGY STAR qualified refrigerator or freezer. This is from the nameplate on the new unit. The default value is 358 kWh.

$STD$  = Average annual consumption of equipment meeting federal standard: Calculated by dividing the  $kWh_{ES}$  by 0.9 (i.e., the Energy Star units are assumed to be 10% more efficient than the  $kWh_{std}$  units). The default value is 398 kWh.

$kWh_{used}$  = Average annual consumption of used equipment. Default value is 475 kWh.<sup>1</sup>

$RUL$  = Remaining Useful life assumed to be 6 years

$EUL$  = Estimated useful life for a new refrigerator is 12 years.<sup>2</sup>

$F_{occ}$  = Occupant adjustment factor used to adjust the energy savings according to the number of occupants in the dwelling unit. See table below. Default is 2.3 occupants per tenant unit

$\Delta kWh = 330$ , using the default assumptions

$kW/kWh$  = Average kW reduction per kWh reduction: 0.00018 kW/kWh<sup>3</sup>

$\Delta kW = 0.06$ , using the default assumptions

**Occupant Adjustment Factor<sup>4</sup>**

| Number of Occupants | F <sub>occ</sub> |
|---------------------|------------------|
| 0 occupants         | 1.00             |
| 1 occupants         | 1.05             |
| 1.8 occupants       | 1.09             |
| 2 occupants         | 1.10             |
| 2.3 occupants       | 1.11             |
| 3 occupants         | 1.13             |
| 4 occupants         | 1.15             |
| 5 occupants         | 1.16             |

**Baseline Efficiency:**

The baseline efficiency case is an existing refrigerator for which the annual kWh may be looked up in a refrigerator database. If the manufacturer and model number are not found, the refrigerator is metered for 1.5 hours in order to determine the annual kWh.

**High Efficiency:**

The high efficiency case is a new more efficiency refrigerator. The manufacturer and model number is looked up in a refrigerator database to determine annual kWh.

**Measure Life:**

The measure life is 12 years.<sup>5</sup>

| Measure Name                           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigerator Replacement (Multifamily) | IE_CD           | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Refrigerator Replacement (Multifamily) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.85             | 0.65             |

**In-Service Rates:**

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

**Realization Rates:**

Realization rates are set to 100% since this measure has not been evaluated.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Refrigerator Replacement (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>7</sup>

| Measure Name                           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigerator Replacement (Multifamily) | IE_CD           | All | \$20.29            | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |

**Endnotes:**

- 1 : Association of Home Appliance Manufacturers (2014 Revised Feb. 2015), Technical Support Document: Early Replacement Program, (Value estimated based on Figure 9 on page 23)
- 2 : Environmental Protection Agency (2014). Savings Calculator for Energy Star Qualified Appliances. [ENERGY STAR 2015 Appliance Calculator](#)
- 3 : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 4 : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 5 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances. [Energy Star 2018 Consumer Appliance Calc](#)
- 6 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 7 : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

## 2.5. Appliance - Refrigerator Replacement - IE Single Family

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-A-RR-SF      |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Appliances      |

### Measure Description:

Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.

### BCR Measure IDs:

| Measure Name                             | Core Initiative                              | BCR Measure ID |
|------------------------------------------|----------------------------------------------|----------------|
| Refrigerator Replacement (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a038        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure                                  | $\Delta kWh$ | $\Delta kW$ |
|------------------------------------------|--------------|-------------|
| Refrigerator Replacement (Single Family) | 762          | 0.13        |

### Baseline Efficiency:

The baseline efficiency case for both the replaced and baseline new refrigerator is an existing refrigerator. It is assumed that low-income customers would otherwise replace their refrigerators with a used inefficient unit.

### High Efficiency:

The high efficiency case is a new Energy Star refrigerator.

### Measure Life:

The measure life is 12 years.<sup>3</sup>

| Measure Name                             | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigerator Replacement (Single Family) | IE_CD           | All | 12  | n/a | n/a | 12  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Refrigerator Replacement (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.85             | 0.65             |

### In-Service Rates:

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

### Realization Rates:

Realization rates are set to 100% since this measure has not been evaluated.

### Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Refrigerator Replacement (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigerator Replacement (Single Family) | IE_CD           | All | \$1.40             | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |

### Endnotes:

1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation.

[CADMUS 2012 Single Family Low Income Impact Eval](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

3 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances.

[Energy Star 2018 Consumer Appliance Calc](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)



## 2.6. Appliance - Secondary Refrigerator/Freezer Removal

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-A-AR         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Appliances      |

### Measure Description:

Removal of second working refrigerator or freezer.

### BCR Measure IDs:

| Measure                           | Core Initiative                              | BCR Measure ID |
|-----------------------------------|----------------------------------------------|----------------|
| Appliance Removal (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a039        |
| Appliance Removal (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a113        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name      | $\Delta kWh$ | $\Delta kW$ |
|-------------------|--------------|-------------|
| Appliance Removal | 874          | 0.15        |

### Baseline Efficiency:

The baseline efficiency case is the old, inefficient secondary working refrigerator or freezer.

### High Efficiency:

The high efficiency case assumes no replacement of secondary unit.

### Measure Life:

The measure life is 5 years.<sup>3</sup>

| Measure Name      | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------|-----------------|-----|-----|-----|-----|-----|
| Appliance Removal | IE_CD           | All | 5   | n/a | n/a | 5   |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Appliance Removal | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.85             | 0.65             |

### In-Service Rates:

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

### Realization Rates:

Realization rates are set to 100% since deemed savings are based on evaluation results.

### Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

| Measure Name      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------|-----------------|-----|------|-----------------|------------------|------|
| Appliance Removal | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

### Non-Energy Impacts:

| Measure Name      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Appliance Removal | IE_CD           | All | \$0.00             | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |

### Endnotes:

- 1 : The Cadmus Group, Inc. (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : Massachusetts Common Assumption.
- 4 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.7. Behavior - Basic Educational Measures

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-A-BEM        |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Appliances      |

### Measure Description:

Installation of basic educational measures during an audit to help customers become more aware of energy efficiency.

### BCR Measure IDs:

| Measure Name                 | Core Initiative                              | BCR Measure ID |
|------------------------------|----------------------------------------------|----------------|
| Participants (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a001        |
| TLC Kit (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a278        |
| Participants (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a277        |
| TLC Kit (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a052        |
| Participant, Gas             | Income Eligible Coordinated Delivery (IE_CD) | GB1a001        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name            | $\Delta kWh$ | $\Delta kW$ |
|-------------------------|--------------|-------------|
| TLC Kit (Single Family) | 69           | 0.01        |
| TLC Kit (Multifamily)   | 69           | 0.01        |

### Baseline Efficiency:

The baseline efficiency case assumes no measures installed.

### High Efficiency:

The high efficiency case includes basic educational measures such as LED nightlights, refrigerator thermostats, hot water thermostats, refrigerator coil brush, wall plate stoppers.

**Measure Life:**

The measure life is 5 years.<sup>3</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| All Measures | IE_CD           | All | 5   | n/a | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| TLC Kit (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.65             | 0.80             |
| TLC Kit (Multifamily)   | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.65             | 0.80             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------|-----------------|-----|------|-----------------|------------------|------|
| TLC Kit (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| TLC Kit (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| TLC Kit (Single Family) | IE_CD           | All | \$0.00             | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |

|                              |       |     |         |        |              |        |        |        |
|------------------------------|-------|-----|---------|--------|--------------|--------|--------|--------|
| TLC Kit (Multifamily)        | IE_CD | All | \$0.00  | \$0.00 | Varies by PA | \$0.01 | \$0.00 | \$0.00 |
| Participant/TLC Kit, Gas     | IE_CD | All | \$7.70  | \$0.00 | \$0.00       | \$0.00 | \$0.00 | \$0.00 |
| Participants (Single Family) | IE_CD | All | \$10.37 | \$0.00 | \$0.00       | \$0.00 | \$0.00 | \$0.00 |
| Participants (Multifamily)   | IE_CD | All | \$7.70  | \$0.00 | \$0.00       | \$0.00 | \$0.00 | \$0.00 |

**Endnotes:**

- 1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : Massachusetts Common Assumption.
- 4 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.8. Building Shell - Air Sealing - IE Multi-Family

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-BS-AS-MF     |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Building Shell  |

### Measure Description:

Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.

### BCR Measure IDs:

| Measure Name                        | Core Initiative                              | BCR Measure ID |
|-------------------------------------|----------------------------------------------|----------------|
| Air Sealing, Electric (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a056        |
| Air Sealing, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a057        |
| Air Sealing, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a058        |
| Air Sealing, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a018        |

### Algorithms for Calculating Primary Energy Impact:

#### Eversource:

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated with custom building simulation model software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to “adding” individual measure results.

**All PAs except Eversource:**

Unit savings are calculated using the following algorithms and assumptions:

$$\text{MMBtu} = (\text{Vol} \times \Delta\text{ACH} \times 0.018 \times \text{HDD60} \times 24) / (1,000,000 * \eta_{\text{heating}})$$

$$\text{kWh} = \text{MMBtu} * 293.1$$

$$\text{kW} = \text{kWh} \times \text{kW/kWh}$$

Where:

Vol = [ft<sup>3</sup>] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)

ΔACH = [°F-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)

HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below.

η<sub>heating</sub> = [AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)

24 = Conversion factor: 24 hours per day

0.018 = [Btu/ft<sup>3</sup>- °F] Air heat capacity: The specific heat of air (0.24 Btu/°F.lb) times the density of air (0.075 lb/ft<sup>3</sup>)

1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu

293.1 = Conversion factor: 293.1 kWh/MMBtu

kW/kWh = Average kW reduction per kWh reduction: 0.00073 kW/kWh<sup>1</sup>

Hours:

Heating hours are characterized by the heating degree days for the facility.<sup>2</sup> The heating degree days are looked up based on the nearest weather station to the customer, as selected by the program vendor.

| TMY3 City               | HDD   | CDH   |
|-------------------------|-------|-------|
| Barnstable Muni Boa     | 4,379 | 1,349 |
| Beverly Muni            | 5,329 | 3,432 |
| Boston Logan Int'l Arpt | 4,450 | 4,329 |
| Chicopee Falls Westo    | 5,016 | 4,116 |
| Lawrence Muni           | 4,640 | 3,978 |
| Marthas Vineyard        | 4,312 | 1,345 |
| Nantucket Memorial AP   | 3,988 | 362   |
| New Bedford Rgnl        | 4,434 | 4,232 |
| North Adams             | 5,234 | 2,524 |
| Norwood Memorial        | 4,872 | 4,763 |
| Otis ANGBb              | 4,718 | 2,588 |

|                          |       |       |
|--------------------------|-------|-------|
| Plymouth Municipal       | 4,559 | 2,138 |
| Provincetown (AWOS)      | 4,368 | 2,195 |
| Westfield Barnes Muni AP | 5,301 | 3,784 |
| Worcester Regional Arpt  | 5,816 | 1,753 |

These values have been derived from TMY3 data downloaded from the National Solar Radiation Data Base. [http://rredc.nrel.gov/solar/old\\_data/nsrdb/1991-2005/tmy3/by\\_state\\_and\\_city.html](http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html). The HDD values were calculated by taking the minimum and maximum temperatures for each day, and calculating a daily average.

### Baseline Efficiency:

The baseline efficiency case is the existing building before the air sealing measure is implemented. The baseline building is characterized by the existing air changes per hour (ACHPRE) for multi-family facilities, which is measured prior to the implementation of the air sealing measure. This will typically be a default value of a baseline/pre-retrofit ACH =0.5.

### High Efficiency:

The high efficiency case is the existing building after the air sealing measure is implemented. The high efficiency building is characterized by the new air changes per hour (ACHPOST) for multi-family facilities, which is measured after the air sealing measure is implemented. This will typically be a default value of a baseline/pre-retrofit ACH =0.4.

### Measure Life:

The measure life is 15 years<sup>3</sup>.

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Air Sealing  | IE_CD           | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

Realization rates are based on study results.<sup>4</sup>

| Measure Name                        | Core Initiative | PA         | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Air Sealing, Electric (Multifamily) | IE_CD           | All        | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Air Sealing, Gas (Multifamily)      | IE_CD           | Berkshire  | 1.00 | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Gas (Multifamily)      | IE_CD           | Columbia   | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Gas (Multifamily)      | IE_CD           | Eversource | 1.00 | n/a             | 1.05             | n/a              | n/a              | n/a              | n/a              |



|                                  |       |               |      |     |      |     |     |     |     |
|----------------------------------|-------|---------------|------|-----|------|-----|-----|-----|-----|
| Air Sealing, Gas (Multifamily)   | IE_CD | Liberty       | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |
| Air Sealing, Gas (Multifamily)   | IE_CD | National Grid | 1.00 | n/a | 0.75 | n/a | n/a | n/a | n/a |
| Air Sealing, Gas (Multifamily)   | IE_CD | Unitil        | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |
| Air Sealing, Oil (Multifamily)   | IE_CD | All           | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |
| Air Sealing, Other (Multifamily) | IE_CD | All           | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |

**In-Service Rates:**

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

**Realization Rates:**

Realization rates are based on evaluation results.<sup>5</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------|-----------------|-----|------|-----------------|------------------|------|
| Air Sealing (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>7</sup>

| Measure Name                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Air Sealing, Electric (Multifamily) | IE_CD           | All | \$389.29           | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |
| Air Sealing, Gas (Multifamily)      | IE_CD           | All | \$389.29           | \$0.00               | \$0.00            | \$0.00              | Varies by PA        | \$0.08                |
| Air Sealing, Oil (Multifamily)      | IE_CD           | All | \$389.29           | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Air Sealing, Other (Multifamily)    | IE_CD           | All | \$389.29           | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |

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**Endnotes:**

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- 1** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 2** : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 3** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 4** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.  
[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 5** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.  
[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 6** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 7** : NMR Group, Inc. (2021). Low Income Multifamily Non-Energy Impact Study  
[2021 NMR LIMF NEI Study TXC50](#)

## 2.9. Building Shell - Insulation - IE Multi-Family

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-BS-I         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Building Shell  |

### Measure Description:

Shell insulation installed through the Residential Coordinated Delivery program.

### BCR Measure IDs:

| Measure Name                       | Core Initiative                              | BCR Measure ID |
|------------------------------------|----------------------------------------------|----------------|
| Insulation, Electric (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a059        |
| Insulation, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a060        |
| Insulation, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a061        |
| Insulation, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a019        |

### Algorithms for Calculating Primary Energy Impact:

#### Eversource:

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated with custom building simulation model software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to “adding” individual measure results.

**kW Factors for HES Vendor Measures<sup>1</sup> :**

| Measure                         | kW/kWh Factor |
|---------------------------------|---------------|
| Insulation (Electric)           | 0.00073       |
| Insulation (Gas, Oil, Other FF) | 0.00076       |

**All PAs except Eversource:**

$$\text{MMBtu} = ((1/R_{\text{exist}} - 1/R_{\text{new}}) * \text{HDD} * 24 * \text{Area}) / (1000000 * \eta_{\text{heat}})$$

$$\text{kWh} = \text{MMBtu} * 293.1$$

$$\text{kW} = \text{kWh} * \text{kW/kWh}_{\text{heat}}$$

Where:

- $R_{\text{exist}}$  = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft<sup>2</sup>-°F/Btuh
- $R_{\text{new}}$  = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft<sup>2</sup>-°F/Btuh
- Area = Square footage of insulated area
- $\eta_{\text{heat}}$  = Efficiency of the heating system (AFUE or COP)
- 293.1 = Conversion constant (1MMBtu = 293.1 kWh)
- 24 = Conversion for hours per day
- HDD = Heating Degree Days; dependent on location, see table below
- 1,000,000 = Conversion from Btu to MMBtu
- kW/kWh<sub>heat</sub> = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

*If Facility has central cooling then also calculate air conditioning savings:*

$$\text{kWh}_{\text{cool}} = ((1/R_{\text{exist}} - 1/R_{\text{new}}) * \text{CDH} * \text{DUA} * \text{Area}) / (1000 \text{ Btu/kBtu} * \eta_{\text{cool}})$$

$$\text{kW} = \text{kWh} * \text{kW/kWh}_{\text{cool}}$$

Where:

- $R_{\text{exist}}$  = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft<sup>2</sup>-°F/Btuh
- $R_{\text{new}}$  = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft<sup>2</sup>-°F/Btuh
- DUA = Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F = 0.75<sup>2</sup>
- Area = Square footage of insulated area
- $\eta_{\text{cool}}$  = Efficiency of air conditioning equipment (SEER or EER)
- CDH = Cooling Degree Hours; dependent on location, see table below
- 1,000,000 = Conversion from Btu to MMBtu
- kW/kWh<sub>cool</sub> = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

*Hours:*

Heating hours are characterized by the heating degree days for the facility.<sup>3</sup> The heating degree days are looked up based on the nearest weather station to the customer, as selected by the program vendor.

| TMY3 City           | HDD   | CDH   |
|---------------------|-------|-------|
| Barnstable Muni Boa | 4,379 | 1,349 |
| Beverly Muni        | 5,329 | 3,432 |

|                          |       |       |
|--------------------------|-------|-------|
| Boston Logan Int'l Arpt  | 4,450 | 4,329 |
| Chicopee Falls Westo     | 5,016 | 4,116 |
| Lawrence Muni            | 4,640 | 3,978 |
| Marthas Vineyard         | 4,312 | 1,345 |
| Nantucket Memorial AP    | 3,988 | 362   |
| New Bedford Rgnl         | 4,434 | 4,232 |
| North Adams              | 5,234 | 2,524 |
| Norwood Memorial         | 4,872 | 4,763 |
| Otis ANGBb               | 4,718 | 2,588 |
| Plymouth Municipal       | 4,559 | 2,138 |
| Provincetown (AWOS)      | 4,368 | 2,195 |
| Westfield Barnes Muni AP | 5,301 | 3,784 |
| Worcester Regional Arpt  | 5,816 | 1,753 |

These values have been derived from TMY3 data downloaded from the National Solar Radiation Data Base. [http://rredc.nrel.gov/solar/old\\_data/nsrdb/1991-2005/tmy3/by\\_state\\_and\\_city.html](http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html). The HDD values were calculated by taking the minimum and maximum temperatures for each day, and calculating a daily average.

### Baseline Efficiency:

The baseline efficiency case is the existing conditions of the participating household.

For high rise the baseline efficiency case is characterized by the total R-value of the existing attic, basement or sidewall (Rexisit). This is calculated as the R-value of the existing insulation, estimated by the program contractor, plus the R-value of the ceiling, floor, or wall (for all projects: RCEILING = 3.36; RFLOOR = 6.16; RWALL = 6.65).<sup>4</sup>

### High Efficiency:

The high efficiency case is characterized by the total R-value of the attic after the installation of additional attic, basement or sidewall insulation. This is calculated as the sum of the existing R-value (Rexisit) plus the R-value of the added insulation.

### Measure Life:

The measure life is 25 years<sup>5</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Insulation   | IE_CD           | All | 25  | n/a | n/a | 25  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                       | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Insulation, Electric (Multifamily) | IE_CD           | All           | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Insulation, Gas (Multifamily)      | IE_CD           | Berkshire     | 1.00 | 1.00            | 0.80             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Gas (Multifamily)      | IE_CD           | Columbia      | 1.00 | 1.00            | 0.96             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Gas (Multifamily)      | IE_CD           | Eversource    | 1.00 | 1.00            | 1.05             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Gas (Multifamily)      | IE_CD           | Liberty       | 1.00 | 1.00            | 0.96             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Gas (Multifamily)      | IE_CD           | National Grid | 1.00 | 1.00            | 0.75             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Gas (Multifamily)      | IE_CD           | Unitil        | 1.00 | 1.00            | 0.96             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Oil (Multifamily)      | IE_CD           | All           | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Other (Multifamily)    | IE_CD           | All           | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PA programs include verification of installations.

**Realization Rates:**

Realization rates are based on evaluation results.<sup>6</sup>

**Coincidence Factor:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------|-----------------|-----|------|-----------------|------------------|------|
| Insulation (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

## Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.<sup>8</sup>

| Measure Name                       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Insulation, Electric (Multifamily) | IE_CD           | All | \$391.20           | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |
| Insulation, Gas (Multifamily)      | IE_CD           | All | \$391.20           | \$0.00               | \$0.00            | \$0.00              | Varies by PA        | \$0.08                |
| Insulation, Oil (Multifamily)      | IE_CD           | All | \$391.20           | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |
| Insulation, Other (Multifamily)    | IE_CD           | All | \$391.20           | \$0.00               | \$0.00            | \$0.00              | \$0.00              | \$0.00                |

### Endnotes:

- 1 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 2 : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 3 : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 4 : Assumptions from National Grid program vendor.
- 5 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 6 : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.  
[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 7 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 8 : NMR Group, Inc. (2021). Low Income Multifamily Non-Energy Impact Study  
[2021 NMR LIMF NEI Study TXC50](#)

## 2.10. Building Shell - Weatherization

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-BS-W         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Building Shell  |

### Measure Description:

Installation of weatherization measures such as air sealing and insulation

### BCR Measure IDs:

| Measure Name                             | Core Initiative                              | BCR Measure ID |
|------------------------------------------|----------------------------------------------|----------------|
| Weatherization, Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a002        |
| Weatherization, Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a003        |
| Weatherization, Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a004        |
| Air Sealing, Electric (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a005        |
| Air Sealing, Oil (Single Family)         | Income Eligible Coordinated Delivery (IE_CD) | EB1a006        |
| Air Sealing, Other (Single Family)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a007        |
| Insulation, Electric (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a008        |
| Insulation, Oil (Single Family)          | Income Eligible Coordinated Delivery (IE_CD) | EB1a009        |
| Insulation, Other (Single Family)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a010        |
| Weatherization, Electric (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a053        |
| Weatherization, Oil (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a054        |
| Weatherization, Other (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a055        |
| Weatherization (Single Family)           | Income Eligible Coordinated Delivery (IE_CD) | GB1a002        |
| Air Sealing, Gas (Single Family)         | Income Eligible Coordinated Delivery (IE_CD) | GB1a003        |
| Insulation, Gas (Single Family)          | Income Eligible Coordinated Delivery (IE_CD) | GB1a004        |



### Algorithms for Calculating Primary Energy Impact:

Unit savings are per home and deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup> All other assumptions are consistent with the Multi Family Offering.

| Measure Name                             | PA  | Energy Type | ΔkWh  | ΔkW  | ΔMMBtu |
|------------------------------------------|-----|-------------|-------|------|--------|
| Weatherization, Electric (Single Family) | All | Electric    | 1,616 | 1.18 |        |
| Weatherization, Oil (Single Family)      | All | Oil         | 377   | 0.60 | 28.1   |
| Weatherization, Other (Single Family)    | All | Propane     | 344   | 0.55 | 26.3   |
| Weatherization, Gas (Single Family)      | All | Gas         | 344   | 0.55 | 26.3   |
| Air Sealing, Electric (Single Family)    | All | Electric    | 501   | 0.37 |        |
| Air Sealing, Oil (Single Family)         | All | Oil         |       |      | 9.9    |
| Air Sealing, Other (Single Family)       | All | Propane     |       |      | 10.5   |
| Air Sealing, Gas (Single Family)         | All | Gas         |       |      | 10.5   |
| Insulation, Electric (Single Family)     | All | Electric    | 1,115 | 0.37 |        |
| Insulation, Oil (Single Family)          | All | Oil         | 377   | 0.60 | 18.2   |
| Insulation, Other (Single Family)        | All | Propane     | 344   | 0.55 | 15.8   |
| Insulation, Gas (Single Family)          | All | Gas         | 344   | 0.55 | 15.8   |

### Baseline Efficiency:

The baseline efficiency case is any existing home shell measures.

### High Efficiency:

The high efficiency case includes the installation of weatherization measures (air sealing & insulation).

### Measure Life:

For the combined weatherization measure the measure life is 20 years.<sup>3</sup> For insulation the measure life is 25 years and for air sealing the measure life is 15 years.

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Air Sealing    | IE_CD           | All | 15  | n/a | n/a | 15  |
| Insulation     | IE_CD           | All | 25  | n/a | n/a | 25  |
| Weatherization | IE_CD           | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Weatherization, Electric (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Weatherization, Oil (Single Family)      | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Weatherization, Other (Single Family)    | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Weatherization, Gas (Single Family)      | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Air Sealing, Electric (Single Family)    | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Air Sealing, Oil (Single Family)         | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Other (Single Family)       | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Gas (Single Family)         | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Insulation, Electric (Single Family)     | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Insulation, Oil (Single Family)          | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Other (Single Family)        | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Insulation, Gas (Single Family)          | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Weatherization, Electric (Multi Family)  | IE_CD           | CLC | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Weatherization, Oil (Multi Family)       | IE_CD           | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |
| Weatherization, Propane (Multi Family)   | IE_CD           | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Weatherization, Electric (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Weatherization, Oil (Single Family)      | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Weatherization, Other (Single Family)    | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Weatherization, Gas (Single Family)      | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Air Sealing, Electric (Single Family)    | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Air Sealing, Oil (Single Family)         | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Air Sealing, Other (Single Family)       | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Air Sealing, Gas (Single Family)         | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Insulation, Electric (Single Family)     | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Insulation, Oil (Single Family)          | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Insulation, Other (Single Family)        | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Insulation, Gas (Single Family)          | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

|                                         |       |     |      |      |      |      |
|-----------------------------------------|-------|-----|------|------|------|------|
| Weatherization, Electric (Multi Family) | IE_CD | CLC | 0.00 | 0.00 | 0.00 | 1.00 |
| Weatherization, Oil (Multi Family)      | IE_CD | CLC | 0.00 | 0.00 | 0.00 | 1.00 |
| Weatherization, Propane (Multi Family)  | IE_CD | CLC | 0.00 | 0.00 | 0.00 | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>5</sup>

| Measure Name                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Weatherization, Electric (Single Family) | IE_CD           | All | \$558.21           |                      | Varies by PA      | \$0.01              |                     |                       |
| Weatherization, Oil (Single Family)      | IE_CD           | All | \$558.21           |                      | Varies by PA      | \$0.01              |                     |                       |
| Weatherization, Other (Single Family)    | IE_CD           | All | \$558.21           |                      | Varies by PA      | \$0.01              |                     |                       |
| Weatherization, Gas (Single Family)      | IE_CD           | All | \$558.21           |                      |                   |                     | Varies by PA        | \$0.08                |
| Air Sealing, Electric (Single Family)    | IE_CD           | All | \$295.21           |                      | Varies by PA      | \$0.01              |                     |                       |
| Air Sealing, Oil (Single Family)         | IE_CD           | All | \$295.21           |                      | Varies by PA      | \$0.01              |                     |                       |
| Air Sealing, Other (Single Family)       | IE_CD           | All | \$295.21           |                      | Varies by PA      | \$0.01              |                     |                       |
| Air Sealing, Gas (Single Family)         | IE_CD           | All | \$295.21           |                      |                   |                     | Varies by PA        | \$0.08                |
| Insulation, Electric (Single Family)     | IE_CD           | All | \$263.00           |                      | Varies by PA      | \$0.01              |                     |                       |
| Insulation, Oil (Single Family)          | IE_CD           | All | \$263.00           |                      | Varies by PA      | \$0.01              |                     |                       |
| Insulation, Other (Single Family)        | IE_CD           | All | \$263.00           |                      | Varies by PA      | \$0.01              |                     |                       |
| Insulation, Gas (Single Family)          | IE_CD           | All | \$263.00           |                      |                   |                     | Varies by PA        | \$0.08                |

|                                            |       |     |          |  |                 |        |  |  |
|--------------------------------------------|-------|-----|----------|--|-----------------|--------|--|--|
| Weatherization, Electric<br>(Multi Family) | IE_CD | CLC | \$771.73 |  | Varies<br>by PA | \$0.01 |  |  |
| Weatherization, Oil<br>(Multi Family)      | IE_CD | CLC | \$771.73 |  | Varies<br>by PA | \$0.01 |  |  |
| Weatherization, Other<br>(Multi Family)    | IE_CD | CLC | \$771.73 |  | Varies<br>by PA | \$0.01 |  |  |

**Endnotes:**

- 
- 1** : The Cadmus Group, Inc (2012). Low Income Single Family Program Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3** : Massachusetts Common Assumption.
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5** : NMR Group, Inc., Tetra Tech (2011). Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

## 2.11. Custom - Income Eligible

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-CM-CMIE      |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Custom          |

### Measure Description:

Vendors install a variety of electric and gas measures at IE multifamily facilities. The measures covered in this entry are associated with commercial gas and electric meters. Measures include HVAC, process, and domestic hot water equipment measures.

### BCR Measure IDs:

| Measure Name                                       | Core Initiative                              | BCR Measure ID |
|----------------------------------------------------|----------------------------------------------|----------------|
| Heating System Retrofit, Heat Pump (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a015        |
| Custom - HVAC (Multifamily)                        | Income Eligible Coordinated Delivery (IE_CD) | EB1a119        |
| Custom - Hot Water (Multifamily)                   | Income Eligible Coordinated Delivery (IE_CD) | EB1a130        |
| Custom - Process (Multifamily)                     | Income Eligible Coordinated Delivery (IE_CD) | EB1a131        |
| Custom - Other (Multifamily)                       | Income Eligible Coordinated Delivery (IE_CD) | EB1a132        |
| Boiler Reset Control, Gas (Multifamily)            | Income Eligible Coordinated Delivery (IE_CD) | GB1a038        |
| Demand Circulator (Multifamily)                    | Income Eligible Coordinated Delivery (IE_CD) | GB1a039        |

### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings estimates for custom IE Multifamily projects are calculated by approved vendors with project-specific details. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis.

### Baseline Efficiency:

For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

### High Efficiency:

The high efficiency scenario is specific to the facility and may include one or more energy efficiency measures.

### Measure Life:

| Measure Name                                       | Core Initiative | PA  | EUL             | OYF | RUL | AML    |
|----------------------------------------------------|-----------------|-----|-----------------|-----|-----|--------|
| Demand Circulator (Multifamily)                    | IE_CD           | All | 15              | n/a | n/a | 15     |
| Boiler Reset Control, Gas (Multifamily)            | IE_CD           | All | 15 <sup>1</sup> | n/a | n/a | 15     |
| Custom HVAC (Multifamily)                          | IE_CD           | All | custom          | n/a | n/a | custom |
| Custom Hot Water (Multifamily)                     | IE_CD           | All | custom          | n/a | n/a | custom |
| Custom Process (Multifamily)                       | IE_CD           | All | custom          | n/a | n/a | custom |
| Custom Other (Multifamily)                         | IE_CD           | All | custom          | n/a | n/a | custom |
| Heating System Retrofit, Heat Pump (Single Family) | IE_CD           | All | 15              | n/a | n/a | 15     |

### Other Resource Impacts:

Other resource impacts are determined on a case by case basis.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name              | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Gas Measures              | IE_CD           | Berkshire     | 1    | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |
| Gas Measures              | IE_CD           | Columbia      | 1    | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Gas Measures              | IE_CD           | Eversource    | 1    | n/a             | 1.05             | n/a              | n/a              | n/a              | n/a              |
| Gas Measures              | IE_CD           | Liberty       | 1    | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Gas Measures              | IE_CD           | National Grid | 1    | n/a             | 0.75             | n/a              | n/a              | n/a              | n/a              |
| Gas Measures              | IE_CD           | Unitil        | 1    | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Custom HVAC (Multifamily) | IE_CD           | All           | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | custom           | custom           |

|                                                    |       |     |      |      |     |      |      |        |        |
|----------------------------------------------------|-------|-----|------|------|-----|------|------|--------|--------|
| Custom Hot Water (Multifamily)                     | IE_CD | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | custom | custom |
| Custom Process (Multifamily)                       | IE_CD | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | custom | custom |
| Custom Other (Multifamily)                         | IE_CD | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | custom | custom |
| Heating System Retrofit, Heat Pump (Single Family) | IE_CD | All | 1.00 | 1.00 | n/a | 1.00 | 1.00 | 0.38   | 0.05   |

**In-Service Rates:**

All installations have 100% in-service rates since all PA programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on an evaluation study.<sup>2</sup>

**Coincidence Factors:**

For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

**Impact Factors for Calculating Net Savings:**

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| All Measures | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>3</sup> Custom - HVAC NEI values for Multifamily are based on 2021 results.<sup>4</sup>

| Measure Name      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Gas Measures      | IE_CD           | All |                    |                      |                   |                     | Varies by PA        | \$0.08                |
| Electric Measures | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |



|                                                    |       |     |          |  |  |  |  |  |
|----------------------------------------------------|-------|-----|----------|--|--|--|--|--|
| Heating System Retrofit, Heat Pump (Single Family) | IE_CD | All | \$310.82 |  |  |  |  |  |
| Custom - HVAC                                      | IE_CD | All | \$836.39 |  |  |  |  |  |

**Endnotes:**

- 1 : ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE. [ACEEE 2006 Emerging Technologies Report Advanced Boiler Controls](#)
- 2 : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 3 : NMR Group, Inc., Tetra Tech (2011). Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)
- 4 : NMR Group, Inc. (2021). Low Income Multifamily Non-Energy Impact Study [2021 NMR LIMF NEI Study TXC50](#)

## 2.12. HVAC - Boiler Reset Control

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-BSC                              |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.

### BCR Measure IDs:

| Measure Name                               | Core Initiative                              | BCR Measure ID |
|--------------------------------------------|----------------------------------------------|----------------|
| Boiler Reset Controls, Oil (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a016        |
| Boiler Reset Control, Gas (Single Family)  | Income Eligible Coordinated Delivery (IE_CD) | GB1a016        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name                              | Core Initiative | ΔMMBtu/Unit |
|-------------------------------------------|-----------------|-------------|
| Boiler Reset Control, Oil (Single Family) | IE_CD           | 4.4         |
| Boiler Reset Control, Gas (Single Family) | IE_CD           | 4.5         |

### Baseline Efficiency:

The baseline efficiency case is a boiler without reset controls.

### High Efficiency:

The high efficiency case is a boiler with reset controls.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name                              | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Boiler Reset Control, Oil (Single Family) | IE_CD           | All | 15  | n/a | n/a | 15  |
| Boiler Reset Control, Gas (Single Family) | IE_CD           | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                              | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Boiler Reset Control, Oil (Single Family) | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Boiler Reset Control, Gas (Single Family) | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

| Measure Name                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Boiler Reset Control, Oil (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Boiler Reset Control, Gas (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>3</sup>

| Measure Name                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Boiler Reset Control, Oil (Single Family) | IE_CD           | All |                    |                      |                   |                     |                     |                       |
| Boiler Reset Control, Gas (Single Family) | IE_CD           | All |                    |                      |                   |                     | Varies by PA        | \$0.08                |

**Endnotes:**

- 1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2 : ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE. [ACEEE 2006 Emerging Technologies Report Advanced Boiler Controls](#)
- 3 : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

## 2.13. HVAC - Boiler Retrofit

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-BR                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Replacement of an old inefficient space heating boiler with a new boiler.

### BCR Measure IDs:

| Measure Name                                           | Core Initiative                              | BCR Measure ID |
|--------------------------------------------------------|----------------------------------------------|----------------|
| Heating System Retrofit, Boiler, Oil (Single Family)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a011        |
| Heating System Retrofit, Boiler, Other (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a012        |
| Heating System Retrofit, Boiler, Gas (Single Family)   | Income Eligible Coordinated Delivery (IE_CD) | GB1a005        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name                                           | Energy Type | ΔMMBtu |
|--------------------------------------------------------|-------------|--------|
| Heating System Retrofit, Boiler, Oil (Single Family)   | Oil         | 20.4   |
| Heating System Retrofit, Boiler, Other (Single Family) | Propane     | 19.4   |
| Heating System Retrofit, Boiler, Gas (Single Family)   | Gas         | 19.4   |

### Baseline Efficiency:

The baseline efficiency case is the existing inefficient boiler.

### High Efficiency:

The high efficiency case is the new efficient boiler.

**Measure Life:**

The measure life is 23 years.<sup>2</sup>

| Measure Name                                    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Heating System Retrofit, Boiler (Single Family) | IE_CD           | All | 23  | n/a | n/a | 23  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System Retrofit, Boiler (Single Family) | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heating System Retrofit, Boiler (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

| Measure Name                                         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System Retrofit, Boiler, Oil (Single Family) | IE_CD           | All | \$310.82           |                      | Varies by PA      | \$0.01              |                     |                       |

|                                                        |       |     |          |  |              |        |              |        |
|--------------------------------------------------------|-------|-----|----------|--|--------------|--------|--------------|--------|
| Heating System Retrofit, Boiler, Other (Single Family) | IE_CD | All | \$310.82 |  | Varies by PA | \$0.01 |              |        |
| Heating System Retrofit, Boiler, Gas (Single Family)   | IE_CD | All | \$310.82 |  |              |        | Varies by PA | \$0.08 |

**Endnotes:**

1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation.

[CADMUS 2012 Single Family Low Income Impact Eval](#)

2 : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Boiler.

[EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Qualified Boiler](#)

## 2.14. HVAC - CVEO Battery Storage Dispatch

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-CVEO-BAT                         |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Active Demand Response                   |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### BCR Measure IDs:

| Measure                                                     | Core Initiative                                  | BCR Measure ID |
|-------------------------------------------------------------|--------------------------------------------------|----------------|
| CVEO Storage Daily Dispatch, discharge (savings) Summer     | Income Eligible Active Demand Reduction (IE_ADR) | CVEO13         |
| CVEO Storage Daily Dispatch, charge (consumption) Summer    | Income Eligible Active Demand Reduction (IE_ADR) | CVEO14         |
| CVEO Storage Targeted Dispatch, discharge (savings) Winter  | Income Eligible Active Demand Reduction (IE_ADR) | CVEO15         |
| CVEO Storage Targeted Dispatch, charge (consumption) Winter | Income Eligible Active Demand Reduction (IE_ADR) | CVEO16         |

Under the Residential Storage Performance Offering, customers are incentivized to decrease demand through the discharge of energy from storage in response to a signal.

The measures in the CVEO initiative planned by CLC are consistent with the Statewide Residential Active Demand Core Initiative. CLC has not yet evaluated Battery Storage and plans to in the near future.

### Algorithms for Calculating Primary Energy Impact:

For Summer Storage Daily Dispatch, unit savings are deemed based on study results.<sup>1</sup>

For Winter Storage Daily Dispatch, unit savings are deemed based on study results.<sup>2</sup>

| PA                     | kW Savings per Battery* |
|------------------------|-------------------------|
| National Grid - Summer | 5.5                     |
| National Grid - Winter | 6.9                     |
| Unitil - Summer        | 1.3                     |
| Unitil - Winter        | 8.3                     |

\* Savings per battery represent the average demand savings (which is equivalent to the battery discharge) during events for batteries that successfully participated.



**Baseline Efficiency:**

For Storage Daily Dispatch, demand and energy impacts of the energy storage are measures assuming the whole-home and solar PV data as the baseline.<sup>3 4</sup>

**High Efficiency:**

N/A, Active Demand Reduction does not directly increase efficiency. Storage increases energy consumption due to round trip efficiency losses.

**Measure Life:**

Because Active Demand Reduction is based on Program Administrators calling demand reduction events each year, the measure life is one year.

| Measure Name         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------|-----------------|-----|-----|-----|-----|-----|
| CVEO Battery Storage | IE_ADR          | CLC | 1   | n/a | n/a | 1   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

For Storage Daily Dispatch, realization rates are set to 100% since deemed savings are based on evaluation results.<sup>5 6</sup>

| Measure Name                                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Storage Daily Dispatch, discharge (savings) Summer     | IE_ADR          | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| Storage Daily Dispatch, discharge (consumption) Summer | IE_ADR          | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 0.00             |
| Storage Daily Dispatch, discharge (savings) Winter     | IE_ADR          | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 1.00             |
| Storage Daily Dispatch, discharge (consumption) Winter | IE_ADR          | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 1.00             |

**Impact Factors for Calculating Net Savings:**

Net-to-gross ratios are assumed to be 1.0 for Income Eligible measures.

| Measure Name         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------|-----------------|-----|------|-----------------|------------------|------|
| CVEO Battery Storage | IE_ADR          | CLC | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

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**Endnotes:**

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- 1 : [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 2 : [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)
- 3 : [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 4 : [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)
- 5 : [2020 Guidehouse Residential Energy Storage Demand Response Summer](#)
- 6 : [2020 Guidehouse Residential Energy Storage Demand Response Winter Season](#)

## 2.15. HVAC - CVEO Solar PV

|                     |                    |
|---------------------|--------------------|
| <b>Measure Code</b> | IE-HVAC-CVEO-SOLPV |
| <b>Market</b>       | Income Eligible    |
| <b>Program Type</b> | Early Replacement  |
| <b>Category</b>     | Other              |

### BCR Measure IDs:

| Measure       | Core Initiative                              | BCR Measure ID |
|---------------|----------------------------------------------|----------------|
| CVEO Solar PV | Income Eligible Coordinated Delivery (IE_CD) | CVEO12         |

### Algorithms for Calculating Primary Energy Impact:

The annual energy (in kWh and kW) produced by the installed solar PV system, accounting for location, system size, system orientation, and capacity factor.

The kWh for a particular system can be estimated using the National Renewable Energy Laboratory (“NREL”) PVWatts Calculator, available at: <https://pvwatts.nrel.gov/>

### Baseline Efficiency:

No Solar PV

### High Efficiency:

Installation of Solar

### Measure Life:

The measure life for a new solar PV system is assumed to be 25 years, consistent with net metering credit availability in Massachusetts. See: <https://www.mass.gov/guides/net-metering-guide>

| Measure Name  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------|-----------------|-----|-----|-----|-----|-----|
| CVEO Solar PV | IE_CD           | CLC | 25  | n/a | n/a | n/a |

### 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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| CVEO Solar PV | IE_CD           | CLC | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.80             | 0.00             |

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are set to 100% until an evaluation occurs.

| Measure Name  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------|-----------------|-----|------|-----------------|------------------|------|
| CVEO Solar PV | IE_CD           | CLC | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B<sup>1</sup>.

| Measure Name  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| CVEO Solar PV | IE_CD           | CLC | \$0.00             | \$0.00               | Varies by PA      | \$0.01              | \$0.00              | \$0.00                |

**Endnotes:**

1 : [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

## 2.16. HVAC - Communicating Thermostat

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-WT                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

A communicating thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems.

### BCR Measure IDs:

| Measure Name                              | Core Initiative                              | BCR Measure ID |
|-------------------------------------------|----------------------------------------------|----------------|
| Wi-Fi Thermostat, AC Only (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a044        |
| Wi-Fi Thermostat, Gas (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a045        |
| Wi-Fi Thermostat, Oil (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a047        |
| Wi-Fi Thermostat, Other (Single Family)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a049        |
| Wi-Fi Thermostat, AC Only (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a095        |
| Wi-Fi Thermostat, Oil (Multifamily)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a096        |
| Wi-Fi Thermostat, Other (Multifamily)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a097        |
| Wi-Fi Thermostat, Gas (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | GB1a014        |
| Wi-Fi Thermostat, Gas (Multifamily)       | Income Eligible Coordinated Delivery (IE_CD) | GB1a036        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1 2</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup> The total cooling savings of 64 kWh were adjusted to reflect the percent of homes that have cooling which based on the Residential Baseline study is 28 percent.

| Measure Name                                         | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|------------------------------------------------------|--------------|-------------|----------------|
| Wi-Fi Thermostat, Electric (AC Only) (Single Family) | 64           | 0.09        |                |

|                                                       |    |      |      |
|-------------------------------------------------------|----|------|------|
| Wi-Fi Thermostat, Gas (Single Family)                 | 18 | 0.03 | 2.79 |
| Wi-Fi Thermostat, Oil (Single Family)                 | 18 | 0.03 | 2.78 |
| Wi-Fi Thermostat, Other (Single Family)               | 18 | 0.03 | 2.78 |
| Wi-Fi Thermostat, Electric (AC Only)<br>(Multifamily) | 64 | 0.09 |      |
| Wi-Fi Thermostat, Gas (Multifamily)                   | 18 | 0.03 | 2.79 |
| Wi-Fi Thermostat, Oil (Multifamily)                   | 18 | 0.03 | 2.78 |
| Wi-Fi Thermostat, Other (Multifamily)                 | 18 | 0.03 | 2.78 |

**Baseline Efficiency:**

The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.

**High Efficiency:**

The high efficiency case is an HVAC system that has a Wi-Fi thermostat installed.

**Measure Life:**

The measure life is 15 years.<sup>4</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Wi-Fi Thermostat | IE_CD           | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Wi-Fi Thermostat, Electric (AC Only) (Single Family) | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |
| Wi-Fi Thermostat, Gas (Single Family)                | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |
| Wi-Fi Thermostat, Oil (Single Family)                | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |
| Wi-Fi Thermostat, Other (Single Family)              | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |

|                                                    |       |     |      |      |      |      |      |      |      |
|----------------------------------------------------|-------|-----|------|------|------|------|------|------|------|
| Wi-Fi Thermostat, Electric (AC Only) (Multifamily) | IE_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.37 | 0.00 |
| Wi-Fi Thermostat, Gas (Multifamily)                | IE_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.37 | 0.00 |
| Wi-Fi Thermostat, Oil (Multifamily)                | IE_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.37 | 0.00 |
| Wi-Fi Thermostat, Other (Multifamily)              | IE_CD | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.37 | 0.00 |

**In-Service Rates:**

All PAs assume 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|------|-----------------|------------------|------|
| Wi-Fi Thermostat | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B. The thermostat NEI values are per household and the PAs adjust the total value by the average number of thermostats per account depending on the initiative. In the case of income eligible, we assume one thermostat per household.

| Measure Name                                         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Wi-Fi Thermostat, Electric (AC Only) (Single Family) | IE_CD           | All | \$44.53            |                      | Varies by PA      | \$0.01              |                     |                       |
| Wi-Fi Thermostat, Gas (Single Family)                | IE_CD           | All | \$44.53            |                      |                   |                     | Varies by PA        | \$0.08                |
| Wi-Fi Thermostat, Oil (Single Family)                | IE_CD           | All | \$44.53            |                      |                   |                     |                     |                       |

|                                                    |       |     |         |  |              |        |              |        |
|----------------------------------------------------|-------|-----|---------|--|--------------|--------|--------------|--------|
| Wi-Fi Thermostat, Other (Single Family)            | IE_CD | All | \$44.53 |  |              |        |              |        |
| Wi-Fi Thermostat, Electric (AC Only) (Multifamily) | IE_CD | All | \$16.02 |  | Varies by PA | \$0.01 |              |        |
| Wi-Fi Thermostat, Gas (Multifamily)                | IE_CD | All | \$16.02 |  |              |        | Varies by PA | \$0.08 |
| Wi-Fi Thermostat, Oil (Multifamily)                | IE_CD | All | \$16.02 |  |              |        |              |        |
| Wi-Fi Thermostat, Other (Multifamily)              | IE_CD | All | \$16.02 |  |              |        |              |        |

**Endnotes:**

- 1** : Navigant Consulting (2018). Wi-Fi Thermostat Impact Evaluation--Secondary Research Study Memo. [2018 Navigant Wi-Fi Thermostat Impact Evaluation Secondary Literature Study](#)
- 2** : Guidehouse (2021). Residential Wi-Fi and Programmable Thermostat Impacts. [2021 Guidehouse Thermostat Impact Study](#)
- 3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 4** : Assumed to have the same lifetime as a regular programmable thermostat. Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat. [EPA 2010 Lifecycle Cost Estimate for ENERGY STAR Programmable Thermostats](#)
- 5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)



## 2.17. HVAC - Duct Insulation

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-DI                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

For existing ductwork in non-conditioned spaces, insulate ductwork.

### BCR Measure IDs:

| Measure Name                              | Core Initiative                              | BCR Measure ID |
|-------------------------------------------|----------------------------------------------|----------------|
| Duct Insulation, Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a135        |
| Duct Insulation, Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a018        |
| Duct Insulation, Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a019        |
| Duct Insulation, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a008        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results<sup>1</sup>:

| Measure Name                              | $\Delta kWh$ | $\Delta kW^2$ | $\Delta MMBtu$ |
|-------------------------------------------|--------------|---------------|----------------|
| Duct Insulation, Electric (Single Family) | 726          | 0.51          |                |
| Duct Insulation, Oil (Single Family)      |              |               | 4.3            |
| Duct Insulation, Other (Single Family)    |              |               | 5.5            |
| Duct Insulation, Gas (Single Family)      |              |               | 5.5            |

### Baseline Efficiency:

The baseline efficiency case is existing, un-insulated ductwork in unconditioned spaces (e.g. attic or basement).

### High Efficiency:

The high efficiency condition is insulated ductwork in unconditioned spaces.

**Measure Life:**

The measure life is 20 years.<sup>3</sup>

| Measure Name    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|-----|
| Duct Insulation | IE_CD           | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                              | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Insulation, Electric (Single Family) | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.22             |
| Duct Insulation, Oil (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Insulation, Other (Single Family)    | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Insulation, Gas (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Insulation, Electric (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Duct Insulation, Oil (Single Family)      | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Duct Insulation, Other (Single Family)    | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Duct Insulation, Gas (Single Family)      | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Insulation, Electric (Single Family) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |
| Duct Insulation, Oil (Single Family)      | IE_CD           | All |                    |                      |                   |                     |                     |                       |
| Duct Insulation, Other (Single Family)    | IE_CD           | All |                    |                      |                   |                     |                     |                       |
| Duct Insulation, Gas (Single Family)      | IE_CD           | All |                    |                      |                   |                     | Varies by PA        | \$0.08                |

**Endnotes:**

- 1** : Cadmus Group (2012). Massachusetts Low Income Single Family Program Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.18. HVAC - Duct Insulation - IE Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-DI-MF                            |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

For existing ductwork in non-conditioned spaces, insulate ductwork.

### BCR Measure IDs:

| Core Initiative                         | Measure Name                                 | BCR Measure ID |
|-----------------------------------------|----------------------------------------------|----------------|
| Duct Insulation, Electric (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a064        |
| Duct Insulation, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a065        |
| Duct Insulation, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a066        |
| Duct Insulation, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a024        |

### Algorithms for Calculating Primary Energy Impact:

#### Eversource:

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated with custom building simulation model software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as

their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to “adding” individual measure results.

**All PAs except Eversource:**

Unit savings are deemed based on study results:

$$\Delta\text{MMBtu} = \text{MMBtu} \times \text{Units}$$

Where:

Unit = Number of square feet of ductwork treated

MMBtu = Average annual MMBtu savings per unit: 0.035<sup>1</sup>

**Baseline Efficiency:**

The baseline efficiency case is existing, un-insulated ductwork in unconditioned spaces (e.g. attic or basement).

**High Efficiency:**

The high efficiency condition is insulated ductwork in unconditioned spaces.

**Measure Life:**

The measure life is 20 years.<sup>2</sup>

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| Duct Insulation (Multifamily) | IE_CD           | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                            | Core Initiative | PA         | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------|-----------------|------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Insulation, Electric (Multifamily) | IE_CD           | All        | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.37             | 0.22             |
| Duct Insulation, Gas (Multifamily)      | IE_CD           | Berkshire  | 1.00 | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |
| Duct Insulation, Gas (Multifamily)      | IE_CD           | Columbia   | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Duct Insulation, Gas (Multifamily)      | IE_CD           | Eversource | 1.00 | n/a             | 1.05             | n/a              | n/a              | n/a              | n/a              |

|                                      |       |               |      |     |      |     |     |     |     |
|--------------------------------------|-------|---------------|------|-----|------|-----|-----|-----|-----|
| Duct Insulation, Gas (Multifamily)   | IE_CD | Liberty       | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |
| Duct Insulation, Gas (Multifamily)   | IE_CD | National Grid | 1.00 | n/a | 0.75 | n/a | n/a | n/a | n/a |
| Duct Insulation, Gas (Multifamily)   | IE_CD | Unitil        | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |
| Duct Insulation, Oil (Multifamily)   | IE_CD | All           | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |
| Duct Insulation, Other (Multifamily) | IE_CD | All           | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on evaluation results.<sup>3</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Insulation (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Insulation, Electric (Multifamily) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |
| Duct Insulation, Gas (Multifamily)      | IE_CD           | All |                    |                      |                   |                     | Varies by PA        | \$0.08                |

|                                            |       |     |  |  |  |  |  |  |
|--------------------------------------------|-------|-----|--|--|--|--|--|--|
| Duct Insulation,<br>Oil (Multifamily)      | IE_CD | All |  |  |  |  |  |  |
| Duct Insulation,<br>Other<br>(Multifamily) | IE_CD | All |  |  |  |  |  |  |

**Endnotes:**

**1** : National Grid Staff Estimate (2010) MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)

**2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**3** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)

## 2.19. HVAC - Duct Sealing - IE Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-DSAF-MF                          |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

For existing ductwork in non-conditioned spaces, seal ductwork. This could include sealing leaky fixed ductwork with mastic or aerosol.

### BCR Measure IDs:

| Measure                              | Core Initiative                              | BCR Measure ID |
|--------------------------------------|----------------------------------------------|----------------|
| Duct Sealing, Electric (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a067        |
| Duct Sealing, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a068        |
| Duct Sealing, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a069        |
| Duct Sealing, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a023        |

### Algorithms for Calculating Primary Energy Impact:

#### Eversource:

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated with custom building simulation model software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to “adding” individual measure results.



**All PAs except Eversource:**

$$\text{MMBtu} = \text{Annual Heating Consumption} \times \% \text{SAVE} \times 1/1,000,000$$

Where:

AnnualHeatingConsumption = The total annual heating consumption for the facility (Btu)

%SAVE = Average reduction in energy consumption.

1/1,000,000 = Conversion from Btu to MMBtu.

**Savings Factors for Multifamily Duct Sealing:**

| Measure Name                          | %SAVE <sup>1</sup> |
|---------------------------------------|--------------------|
| Surface Area < 50 SQFT                | 7%                 |
| Surface Area > 50 SQFT and < 200 SQFT | 3%                 |
| Surface Area > 200 SQFT               | 1%                 |

**Baseline Efficiency:**

The baseline efficiency case is existing, non-sealed (leaky) ductwork in unconditioned spaces (e.g. attic or basement).

**High Efficiency:**

The high efficiency condition is air sealed ductwork in unconditioned spaces.

**Measure Life:**

The measure life is 20 years.<sup>2</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Duct Sealing | IE_CD           | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                         | Core Initiative | PA         | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------|-----------------|------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Sealing, Electric (Multifamily) | IE_CD           | All        | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.37             | 0.22             |
| Duct Sealing, Gas (Multifamily)      | IE_CD           | Berkshire  | 1.00 | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Gas (Multifamily)      | IE_CD           | Columbia   | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Gas (Multifamily)      | IE_CD           | Eversource | 1.00 | n/a             | 1.05             | n/a              | n/a              | n/a              | n/a              |

|                                   |       |               |      |     |      |     |     |     |     |
|-----------------------------------|-------|---------------|------|-----|------|-----|-----|-----|-----|
| Duct Sealing, Gas (Multifamily)   | IE_CD | Liberty       | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |
| Duct Sealing, Gas (Multifamily)   | IE_CD | National Grid | 1.00 | n/a | 0.75 | n/a | n/a | n/a | n/a |
| Duct Sealing, Gas (Multifamily)   | IE_CD | Unitil        | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |
| Duct Sealing, Oil (Multifamily)   | IE_CD | All           | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |
| Duct Sealing, Other (Multifamily) | IE_CD | All           | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on evaluation results.<sup>3</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Sealing, Electric (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Sealing, Electric  | IE_CD           | All | \$1.04             |                      | Varies by PA      | \$0.01              |                     |                       |
| Duct Sealing, Gas       | IE_CD           | All | \$1.04             |                      |                   |                     | Varies by PA        | \$0.08                |
| Duct Sealing, Oil/Other | IE_CD           | All | \$1.04             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1** : Savings assumptions from National Grid program vendor.
- 2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 3** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.  
[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)

## 2.20. HVAC - Duct Sealing - IE Single Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-DSAF                             |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

For existing ductwork in non-conditioned spaces, seal ductwork. This could include sealing leaky fixed ductwork with mastic or aerosol.

### BCR Measure IDs:

| Measure Name                           | Core Initiative                              | BCR Measure ID |
|----------------------------------------|----------------------------------------------|----------------|
| Duct Sealing, Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | E19B1a020      |
| Duct Sealing, Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | E19B1a021      |
| Duct Sealing, Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | E19B1a136      |
| Duct Sealing, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | G19B1a007      |

### Algorithms for Calculating Primary Energy Impact:

1Unit savings are deemed based on study results.<sup>1 2</sup>

| Measure Name                           | $\Delta kWh$ | $\Delta kW^3$ | $\Delta MMBtu$ |
|----------------------------------------|--------------|---------------|----------------|
| Duct Sealing, Electric (Single Family) | 442          | 0.31          |                |
| Duct Sealing, Oil (Single Family)      |              |               | 3.3            |
| Duct Sealing, Other (Single Family)    |              |               | 3.3            |
| Duct Sealing, Gas (Single Family)      |              |               | 3.3            |

### Baseline Efficiency:

The baseline efficiency case is existing, non-sealed (leaky) ductwork in unconditioned spaces (e.g. attic or basement).

### High Efficiency:

The high efficiency condition is air sealed ductwork in unconditioned spaces.

**Measure Life:**

The measure life is 20 years.<sup>4</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Duct Sealing | IE_CD           | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Sealing, Electric (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.37             | 0.22             |
| Duct Sealing, Gas (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Oil (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Sealing, Other (Single Family)    | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluated results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are based on evaluation results.

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Sealing | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Sealing, Electric  | IE_CD           | All | \$6.21             |                      | Varies by PA      | \$0.01              |                     |                       |
| Duct Sealing, Gas       | IE_CD           | All | \$6.21             |                      |                   |                     | Varies by PA        | \$0.08                |
| Duct Sealing, Oil/Other | IE_CD           | All | \$6.21             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1** : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2** : For Electric : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. [2018 Navigant HES Impact Evaluation](#)
- 3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 4** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.21. HVAC - Furnace Retrofit

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-FR                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Replacement of an old inefficient space heating furnace with a new furnace.

### BCR Measure IDs:

| Measure Name                                            | Core Initiative                              | BCR Measure ID |
|---------------------------------------------------------|----------------------------------------------|----------------|
| Heating System Retrofit, Furnace, Oil (Single Family)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a013        |
| Heating System Retrofit, Furnace, Other (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a014        |
| Heating System Retrofit, Furnace, Gas (Single Family)   | Income Eligible Coordinated Delivery (IE_CD) | GB1a006        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup> Electric savings can be attributed to reduced fan run time.

| Measure Name                                            | Energy Type | MMBtu/unit | kWh/Unit | kW/Unit <sup>2</sup> |
|---------------------------------------------------------|-------------|------------|----------|----------------------|
| Heating System Retrofit, Furnace, Oil (Single Family)   | Oil         | 14.3       | 132      | 0.10                 |
| Heating System Retrofit, Furnace, Other (Single Family) | Propane     | 20.7       | 172      | 0.13                 |
| Heating System Retrofit, Furnace, Gas (Single Family)   | Gas         | 20.7       | 172      | 0.13                 |

### Baseline Efficiency:

The baseline efficiency case is the existing inefficient furnace.

**High Efficiency:**

The high efficiency case is the new efficient furnace.

**Measure Life:**

The measure life is 17 years.<sup>3</sup>

| Measure Name                                     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Heating System Retrofit, Furnace (Single Family) | IE_CD           | All | 17  | n/a | n/a | 17  |

**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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System Retrofit, Furnace (Single Family) | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |

**In-Service Rates**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                                     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heating System Retrofit, Furnace (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.



| Measure Name                                | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System Retrofit, Furnace, Oil/Other | IE_CD           | All | \$310.82           |                      | Varies by PA      | \$0.01              |                     |                       |
| Heating System Retrofit, Furnace, Gas       | IE_CD           | All | \$310.82           |                      |                   |                     | Varies by PA        | \$0.08                |

**Endnotes:**

- 1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Furnace. [EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Furnace](#)
- 4 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.22. HVAC - Heat Pump - IE - Custom

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-HP-C                             |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of a heat pump to displace electric, oil, or propane heat.

### BCR Measure IDs:

| Measure Name                                               | Core Initiative                              | BCR Measure ID |
|------------------------------------------------------------|----------------------------------------------|----------------|
| Custom - Heat Pumps displacing Electric Heat (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a274        |
| Custom - Heat Pumps displacing Oil (Multifamily)           | Income Eligible Coordinated Delivery (IE_CD) | EB1a275        |
| Custom - Heat Pumps displacing Propane (Multifamily)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a276        |
| CVEO Heat Pumps, Electric Heat                             | Income Eligible Coordinated Delivery (IE_CD) | CVEO9          |
| CVEO Heat Pumps, Oil                                       | Income Eligible Coordinated Delivery (IE_CD) | CVEO10         |
| CVEO Heat Pumps, Propane                                   | Income Eligible Coordinated Delivery (IE_CD) | CVEO11         |

### Algorithms for Calculating Primary Energy Impact:

For custom, heat pump savings will be calculated by the vendor based on existing site conditions.

For CVEO, heat pump savings will be calculated using the same assumptions and methods as the measures shown in the following table. In addition, all assumptions for these measures will be based on the BCR Measure Data Source.

| Measure Name                   | Core Initiative                              | BCR Measure ID | PA  | BCR Measure Data Source |
|--------------------------------|----------------------------------------------|----------------|-----|-------------------------|
| CVEO Heat Pumps, Electric Heat | Income Eligible Coordinated Delivery (IE_CD) | CVEO9          | CLC | EB1a266                 |

| Measure Name             | Core Initiative                              | BCR Measure ID | PA  | BCR Measure Data Source                                        |
|--------------------------|----------------------------------------------|----------------|-----|----------------------------------------------------------------|
| CVEO Heat Pumps, Oil     | Income Eligible Coordinated Delivery (IE_CD) | CVEO10         | CLC | EB1a269<br>EB1a273<br>EB1a271<br>EB1a286<br>EB1a281<br>EB1b284 |
| CVEO Heat Pumps, Propane | Income Eligible Coordinated Delivery (IE_CD) | CVEO1          | CLC | EB1a268<br>EB1a272<br>EB1a270<br>EB1a287<br>EB1a282<br>EB1b285 |

**Baseline Efficiency:**

For custom, the baseline efficiency case is existing site conditions.

**High Efficiency:**

For custom, the high efficiency case varies depending on the equipment installed.

**Measure Life:**

The measure life will vary depending on the actual equipment installed.

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                              | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Custom Heat Pumps, Displacing Electric Heat (Multifamily) | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |
| Custom Heat Pumps, Displacing Oil (Multifamily)           | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | Custom           | Custom           |
| Custom Heat Pumps, Displacing Propane (Multifamily)       | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | Custom           | Custom           |

**In-Service Rates:**

All installations have 100% in-service rates since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% because the measure is new and has not been evaluated.

**Coincidence Factors:**

For replacing electric baseboard summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>1</sup> Coincidence factors for fuel switching will be custom calculated based on site conditions.

**Impact Factors for Calculating Net Savings:**

NTG rates are set to 100% because the measure is new and has not been evaluated.

| Measure Name                                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Custom Heat Pumps, Displacing Electric Heat (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Custom Heat Pumps, Displacing Oil (Multifamily)           | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Custom Heat Pumps, Displacing Propane (Multifamily)       | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>2</sup>

| Measure Name                                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Custom Heat Pumps, Displacing Electric Heat (Multifamily) | IE_CD           | All | \$836.39           |                      | \$0.05            | \$0.01              |                     |                       |
| Custom Heat Pumps, Displacing Oil (Multifamily)           | IE_CD           | All | \$836.39           |                      | \$0.05            | \$0.01              |                     |                       |
| Custom Heat Pumps, Displacing Propane (Multifamily)       | IE_CD           | All | \$836.39           |                      | \$0.05            | \$0.01              |                     |                       |

**Endnotes:**

**1** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)

**2** : NMR Group, Inc. (2021). Low Income Multifamily Non-Energy Impact Study  
[2021 NMR LIMF NEI Study TXC50](#)

## 2.23. HVAC - Heat Pump Displacing Existing Electric Resistance Heat

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-FS-DMSDEH                        |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

The displacement of electric resistance heating with a more efficient ductless mini-split heat pump (DMSHP) system.

### BCR Measure IDs:

| Measure Name                                   | Core Initiative                              | BCR Measure ID |
|------------------------------------------------|----------------------------------------------|----------------|
| DMSHP displacing Electric Heat (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a266        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings.<sup>1</sup> Savings were calculated via simulation model runs assuming a full displacement of the areas of the home being displaced by the heat pump.<sup>2</sup>

Capacity of new Heat Pump = 2.0 Tons<sup>3</sup>

| Measure Name                   | Saved MMBtu Oil/Propane/Gas Per Ton/Per Whole Home | ΔkW Per Ton/Per Whole Home | ΔkWh Per Ton/Per Whole Home |
|--------------------------------|----------------------------------------------------|----------------------------|-----------------------------|
| DMSHP displacing Electric Heat | N/A                                                | 2.57/<br>5.13              | 2316/<br>4631               |

### Baseline Efficiency:

For displacement of electric heat, the equivalent HSPF for electric resistance heat is assumed to be 3.41 COP.<sup>9</sup>

**High Efficiency:**

For the minimum program qualifications, the high efficiency case is a 2.0-ton, SEER 16, HSPF 9.5

**Measure Life:**

The measure life is based on evaluation results.<sup>10</sup>

| Measure Name                   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------|-----------------|-----|-----|-----|-----|-----|
| DMSHP displacing Electric Heat | IE_CD           | All | 18  | N/A | N/A | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| DMSHP displacing Electric Heat | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.02             | 0.31             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>11</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------|
| DMSHP displacing Electric Heat | IE_CD           | All | 00.0 | 00.0            | 00.0             | 1,00 |

## Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| DMSHP displacing Electric Heat | IE_CD           | All | \$0.00             | \$0.00               | Varies by PA      | \$0.005             | N/A                 | N/A                   |

## Endnotes:

- 1** : Savings were derived from energy simulation models that came from 2020 MA20R24 Heat Pump Fuel Displacement Study. The results can be found in the attached excel file. [2022-2024 Annual Plan EO Measures BCR Model - EO Eval Update - 09-01-2021](#)
- 2** : More details on study methodology can be found here: (will update when we have final study results).
- 3** : Tonnage sizes were calculated based on 2019 production in the residential retail program and can be found in the following evaluation study (will be updated when study is final).
- 9** : The Cadmus Group, Inc. (2016). Ductless Mini Split Heat Pump Impact Evaluation [Cadmus 2016 DMSHP Impact Evaluation](#)
- 10** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 11** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)



## 2.24. HVAC - Heat Pump Fully Displacing Existing Boiler

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-FS-DMSHP                         |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Full displacement of a boiler with a high efficiency ductless minisplit heat pump for heating.

### BCR Measure IDs:

| Measure Name                                    | Core Initiative | BCR Measure ID |
|-------------------------------------------------|-----------------|----------------|
| DMSHP Fully Displacing Existing Boiler, Oil     | Income Eligible | EB1a286        |
| DMSHP Fully Displacing Existing Boiler, Propane | Income Eligible | EB1a287        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings.<sup>1</sup> Savings were calculated via simulation model runs assuming the existing heating system will be fully displaced.<sup>2</sup>

Capacity of new Heat Pump = 3.9 tons<sup>3</sup>

| Measure Name                                       | Saved MMBtu<br>Oil/Propane/Gas<br>Per Ton/Per Whole Home | $\Delta$ kW<br>Per Ton/Per<br>Whole Home | $\Delta$ kWh<br>Per Ton/Per<br>Whole Home |
|----------------------------------------------------|----------------------------------------------------------|------------------------------------------|-------------------------------------------|
| DMSHP Fully Displacing<br>Existing Boiler, Oil     | 17.78/<br>69.33                                          | -0.56<br>-2.19                           | -1508/<br>-5882                           |
| DMSHP Fully Displacing<br>Existing Boiler, Propane | 17.78/<br>69.33                                          | -0.56<br>-2.19                           | -1508/<br>-5882                           |

### Baseline Efficiency:

For propane the baseline is an existing inefficient boiler at 77.4% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83.7% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program

intervention. For oil the baseline is an existing inefficient boiler at 79.4% AFUE furnace when the customer survey responses stated that the existing unit was functioning properly and a 86% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SSEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention.

**High Efficiency:**

For the minimum program qualifications, the high efficiency case is a new 16 SEER/9.5 HSPF ductless mini split heat pumps.

**Measure Life:**

| Measure Name                           | Core Initiative | PA  | EUL <sup>4</sup> | OYF | RUL | AML |
|----------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| DMSHP Fully Displacing Existing Boiler | IE_CD           | All | 18               | n/a | n/a | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| DMSHP Fully Displacing Existing Boiler | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.039            | 0.21             |

**In-Service Rates:**

All installations have 100% in-service rates 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 <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>5</sup> |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| DMSHP Fully Displacing Existing Boiler | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00             |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                    | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| DMSHP Fully Displacing Existing Boiler, Oil     | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |
| DMSHP Fully Displacing Existing Boiler, Propane | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |

**Endnotes:**

- 1 : Savings were derived from energy simulation models that came from 2020 MA20R24 Heat Pump Fuel Displacement Study. The results can be found in the attached excel file. [Fuel Displacement Eval Measure Impacts - 2021-09-10](#)
- 2 : For more information on the weighting, please refer to the evaluation study. [2021 Guidehouse Fuel Displacement Report HP](#)
- 3 : Tonnage sizes were calculated based on 2019 production in the residential retail program and can be found in the following evaluation study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 4 : Measure life Air source heat Pump GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 5 : The income eligible sector assumes a 100% NTG value.

## 2.25. HVAC - Heat Pump Fully Displacing Existing Furnace

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-FSHP                             |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Full displacement of an existing inefficient propane or oil furnace with a high efficiency central ducted heat pump.

### BCR Measure IDs:

| Measure Name                                                                        | Core Initiative                              | BCR Measure ID |
|-------------------------------------------------------------------------------------|----------------------------------------------|----------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a273        |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a272        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings.<sup>1</sup> Savings were calculated via simulation model runs assuming the existing heating system will be fully displaced.<sup>2</sup>

Capacity of new Heat Pump = 4.7 tons<sup>3</sup>

| Measure Name                                                        | Saved MMBtu Oil/Propane/Gas Per Ton/Per Whole Home | ΔkW             | ΔkWh            |
|---------------------------------------------------------------------|----------------------------------------------------|-----------------|-----------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | 17.85/<br>83.91                                    | -0.75/<br>-3.53 | -1795/<br>-8437 |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | 17.85/<br>83.91                                    | -0.75/<br>-3.53 | -1795/<br>-8437 |

**Baseline Efficiency:**

For propane the baseline is an existing inefficient furnace at 81% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 90.1% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention. For oil the baseline is an existing inefficient furnace at 77.7% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SSEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention. <sup>3</sup>

**High Efficiency:**

For the minimum program qualifications, the high efficiency case is a new 4.7 ton 16 SEER/9.5 HSPF ducted central heat pump.

**Measure Life:**

The measure life is 17 years.

| Measure Name                                                    | Core Initiative | PA  | EUL <sup>4</sup> | OYF | RUL | AML |
|-----------------------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil | IE_CD           | All | 17               | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.02            | 0.65             |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | RES_RETAIL      | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.02            | 0.65             |

**In-Service Rates:**

All installations have 100% in-service rates 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 calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil     | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |
| Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |

**Endnotes:**

**1** : Savings were derived from energy simulation models that came from 2020 MA20R24 Heat Pump Fuel Displacement Study. The results can be found in the attached excel file. [2021 Guidehouse Fuel Displacement Report HP](#)

**2** : Further information on the methodology used to calculate the overall savings can be found here: [2021 Guidehouse Fuel Displacement Report HP](#)

**3** : Tonnage sizes were calculated based on 2019 production in the residential retail program and can be found in the following evaluation study: [2021 Guidehouse Fuel Displacement Report HP](#)

**3** : Further information on the methodology used to calculate the overall savings can be found here: (Will update when study has been finalized).

**4** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Measure life Air source heat Pump  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

## 2.26. HVAC - Heat Pump Partially Displacing Existing Boiler

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-FS-DMSHP-P                       |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Partial displacement of a boiler with a high efficiency ductless minisplit heat pump for heating.

### BCR Measure IDs:

| Measure Name                                                                                 | Core Initiative                              | BCR Measure ID |
|----------------------------------------------------------------------------------------------|----------------------------------------------|----------------|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a271        |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a270        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. Cooling savings are based on survey responses and include central air conditioning, room air conditioning and no AC. These different types of AC are weighted to supply the overall AC savings. Savings were calculated via simulation model runs assuming using a weighted average of survey responses for the most accurate switch over temperature between the MSHP and the secondary heating source. Due to expected program changes, the weighting were updated for each year of the three year plan showing better control strategies for propane throughout the three year plan. <sup>1 2</sup>

Capacity of new Heat Pump = 2.8 Tons <sup>3</sup>

| Year        | Measure Name                             | Saved MMBtu Oil/Propane/Gas Per Ton/Per Home | ΔkW Per Ton/Per Home | ΔkWh Per Ton/Per Home |
|-------------|------------------------------------------|----------------------------------------------|----------------------|-----------------------|
| 2022 - 2024 | DMSHP with Integrated Controls Partially | 15.8/<br>44.3                                | -0.32/<br>-0.89      | -994/<br>-2784        |

|      |                                                                              |                |                 |                 |
|------|------------------------------------------------------------------------------|----------------|-----------------|-----------------|
|      | Displacing Existing Boiler, Oil                                              |                |                 |                 |
| 2022 | DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | 17.18/<br>48.1 | -0.37/<br>-1.04 | -1122/<br>-3141 |
| 2023 | DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | 18.1/<br>50.6  | -0.40/<br>-1.13 | -1193/<br>-3340 |
| 2024 | DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | 19.0/<br>53.1  | -.043/<br>-1.21 | -1264/<br>-3538 |

**Baseline Efficiency:**

For propane the baseline is an existing inefficient boiler at 77.4% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83.7% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention. For oil the baseline is an existing inefficient furnace at 79.4% AFUE boiler when the customer survey responses stated that the existing unit was functioning properly and a 86% AFUE efficiency when the customer survey responses stated the customer would have installed a new boiler without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SSEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention.

**High Efficiency:**

For the minimum program qualifications, the high efficiency case is a new 16 SEER/9.5 HSPF ductless mini split heat pumps.

**Measure Life:**

| Measure Name                                                        | Core Initiative | PA  | EUL <sup>4</sup> | OYF | RUL | AML |
|---------------------------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler | IE_CD           | All | 18               | n/a | n/a | 18  |

**Other Resource Impacts:**



There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                        | Core Initiative | PA  | ISR  | RRE  | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------------------------|-----------------|-----|------|------|------------------|------------------|------------------|------------------|------------------|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler | IE_CD           | All | 1.00 | 1.00 | 1.00             | 1.00             | 1.00             | 0.016            | 0.73             |

**In-Service Rates:**

All installations have 100% in-service rates 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 <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                                                                 | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil (Single Family)     | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |
| DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane (Single Family) | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |

**Endnotes:**

- 1 : Savings were derived from energy simulation models that came from the following study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 2 : For more information on the weighting and savings calculations please refer to the evaluation report: [2021 Guidehouse Fuel Displacement Report HP](#)
- 3 : Tonnage sizes were calculated based on 2019 production in the residential retail program and can be found in the following evaluation study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 4 : Measure life Air source heat Pump GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

## 2.27. HVAC - Heat Pump Partially Displacing Existing Furnace

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-FSHP-P                           |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Partial displacement of an existing propane or oil furnace with a high efficiency central ducted heat pump.

### BCR Measure IDs:

| Measure Name                                                                            | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------------------------------------------------|----------------------------------------------|----------------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a269        |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a268        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a per ton savings: For planning purposes, savings are then calculated or scaled to represent results based on the average tonnage size per home through 2019 production in the residential retail program offering activity by multiplying the per ton savings by the capacity of the heat pump in tons. These different types of AC are weighted to supply the overall AC savings. Energy Savings were calculated via energy simulation models. The crossover temp was modeled at several different crossover temps via customer survey responses and the results were weighted by the distribution of responses. Due to expected program changes, the weighting were updated for each year of the three year plan showing better control strategies for propane throughout the three year plan.<sup>1 2</sup>

Capacity of new Heat Pump = 3.7 tons Tons<sup>3</sup>

| Year      | Measure Name                                                        | Saved MMBtu Oil/Propane/Gas Per Ton/Per Home | ΔkW             | ΔkWh           |
|-----------|---------------------------------------------------------------------|----------------------------------------------|-----------------|----------------|
| 2022-2024 | Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil | 12.7/47.0                                    | -0.36/<br>-1.34 | -900/<br>-3328 |

|      |                                                                         |            |                 |                 |
|------|-------------------------------------------------------------------------|------------|-----------------|-----------------|
| 2022 | Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | 14.5/53.8  | -0.43/<br>-1.57 | -1047/<br>-3873 |
| 2023 | Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | 16.9/62.5  | -0.53/<br>-1.96 | -1292/<br>-4781 |
| 2024 | Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | 17.85/66.1 | -0.57/<br>-2.12 | -1390/<br>-5144 |

**Baseline Efficiency:**

For propane the baseline is an existing inefficient furnace at 81% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 90.1% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention. For oil the baseline is an existing inefficient furnace at 77.7% AFUE when the customer survey responses stated that the existing unit was functioning properly and a 83% AFUE efficiency when the customer survey responses stated the customer would have installed a new furnace without program intervention.

The cooling baseline is a weighted average of the existing inefficient Central AC at 12 SEER, 11.4 EER Room AC and a load building no AC situation when the customer survey responses stated that the existing unit was functioning properly and a weighted average 14 SEER Central AC, 11 EER Room AC and a load building no AC situation when the customer survey responses stated the customer would have installed a new AC unit without program intervention. <sup>4</sup>

**High Efficiency:**

For the minimum program qualifications, the high efficiency case is a new efficient 3.7 ton 16 SEER/9.5 HSPF ducted central heat pump.

**Measure Life:**

| Measure Name                                                   | Core Initiative | PA  | EUL <sup>5</sup> | OYF | RUL | AML |
|----------------------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Central Ducted Heat Pump Partially Displacing Existing Furnace | IE_CD           | All | 17               | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil     | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.05            | 0.70             |

**In-Service Rates:**

All installations have 100% in-service rates 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 calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                                                            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil (Single Family)     | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |
| Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane (Single Family) | IE_CD           | All | 0                  | 0                    | Varies by PA      | 0.005               |                     |                       |

## **Endnotes:**

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- 1** : Savings were derived from energy simulation models that came in the following study:  
[2021 Guidehouse Fuel Displacement Report HP](#)
- 2** : Further information can be found on the methodology used to calculate savings in the following report: [2021 Guidehouse Fuel Displacement Report HP](#)
- 3** : Tonnage sizes were calculated based on 2019 production via the retail program delivery and can be found in the following evaluation study: [2021 Guidehouse Fuel Displacement Report HP](#)
- 4** : Further information on the baseline and the associated baseline weights can be found in the following report: [2021 Guidehouse Fuel Displacement Report HP](#)
- 5** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

## 2.28. HVAC - Heating System

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-HS                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of high efficiency heating equipment to replace the existing inefficient furnace, hydronic boiler or steam boiler.

### BCR Measure IDs:

| Measure Name                                        | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------------|----------------------------------------------|----------------|
| Heating System Retrofit, Boiler, Gas (Multifamily)  | Income Eligible Coordinated Delivery (IE_CD) | GB1a020        |
| Heating System Retrofit, Furnace, Gas (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | GB1a021        |
| Heating System, Commercial Boiler (Multifamily)     | Income Eligible Coordinated Delivery (IE_CD) | GB1a022        |

### Algorithms for Calculating Primary Energy Impact:

#### Eversource:

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated with custom building simulation model software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to “adding” individual measure results.

**All PAs except Eversource:**

$$\Delta\text{MMBtu} = \text{Btu/hr} \times (1/\text{AFUE}_{\text{BASE}} - 1/\text{AFUE}_{\text{EE}}) \times \text{EFLH}_{\text{heat}} \times (1/1000000)$$

Where:

- Btu/hr = Nominal heating capacity of the installed equipment (Btu/hr)
- AFUE<sub>BASE</sub> = Average fuel utilization efficiency of the existing equipment (%)
- AFUE<sub>EE</sub> = Average fuel utilization efficiency of the efficient equipment (%)
- EFLH<sub>Heat</sub> = Equivalent full load heating hours for the facility (Hr)
- 1/1,000,000 = Conversion from Btu to MMBtu

**Baseline Efficiency:**

The baseline efficiency case is the existing inefficient heating system.

**High Efficiency:**

The high efficiency case is characterized by the rated efficiency (AFUE<sub>EE</sub>) of the new high efficiency furnace or boiler.

**Measure Life:**

| Measure Name                               | Core Initiative | PA  | EUL             | OYF | RUL | AML    |
|--------------------------------------------|-----------------|-----|-----------------|-----|-----|--------|
| Heating System Retrofit, Boiler            | IE_CD           | All | 20 <sup>1</sup> | n/a | n/a | 20     |
| Heating System Retrofit, Furnace           | IE_CD           | All | 18 <sup>2</sup> | n/a | n/a | 18     |
| Heating System Retrofit, Commercial Boiler | IE_CD           | All | custom          | n/a | n/a | custom |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                      | Program | PA         | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------|---------|------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System, Gas (Multifamily) | IE_CD   | Berkshire  | 1.00 | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |
| Heating System, Gas (Multifamily) | IE_CD   | Columbia   | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Heating System, Gas (Multifamily) | IE_CD   | Eversource | 1.00 | n/a             | 1.05             | n/a              | n/a              | n/a              | n/a              |
| Heating System, Gas (Multifamily) | IE_CD   | Liberty    | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |



|                                   |       |               |      |     |      |     |     |     |     |
|-----------------------------------|-------|---------------|------|-----|------|-----|-----|-----|-----|
| Heating System, Gas (Multifamily) | IE_CD | National Grid | 1.00 | n/a | 0.75 | n/a | n/a | n/a | n/a |
| Heating System, Gas (Multifamily) | IE_CD | Unitil        | 1.00 | n/a | 0.96 | n/a | n/a | n/a | n/a |

**In-Service Rates:**

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

**Realization Rates:**

The realization rate is based on evaluation results.<sup>3</sup>

**Coincidence Factors:**

There are no electric savings for this measure.

**Impact Factors for Calculating Net Savings:**

| Measure Name                               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heating System Retrofit, Boiler            | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Heating System Retrofit, Furnace           | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Heating System Retrofit, Commercial Boiler | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                               | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heating System Retrofit, Boiler            | IE_CD           | All | \$836.39           |                      |                   |                     | Varies by PA        | \$0.08                |
| Heating System Retrofit, Furnace           | IE_CD           | All | \$836.39           |                      |                   |                     | Varies by PA        | \$0.08                |
| Heating System Retrofit, Commercial Boiler | IE_CD           | All | \$836.39           |                      |                   |                     | Varies by PA        | \$0.08                |

**Endnotes:**

**1** : Federal Register Title 10 Chapter II Subchapter D Part 430 Subpart C § 430.32. Up to date as of 10/08/2021. <https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32>

**1** : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers. [EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Qualified Boiler](#)

**2** : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Furnace. [EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Furnace](#)

**3** : The Cadmus Group, Inc. (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)

## 2.29. HVAC - Pipe Wrap (Heating)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-PW                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Insulation upgrades to existing heating system pipes

### BCR Measure IDs:

| Measure Name                             | Core Initiative                              | BCR Measure ID |
|------------------------------------------|----------------------------------------------|----------------|
| Pipe Wrap (Heating), Oil (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a137        |
| Pipe Wrap (Heating), Oil (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a073        |
| Pipe Wrap (Heating) (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | GB1a026        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name                             | $\Delta$ MMBtu |
|------------------------------------------|----------------|
| Pipe Wrap (Heating), Gas (Multifamily)   | 1.14           |
| Pipe Wrap (Heating), Oil (Single Family) | 1.14           |
| Pipe Wrap (Heating), Oil (Multifamily)   | 1.14           |

### Baseline Efficiency:

The baseline efficiency case is the existing equipment prior to the installation of additional insulation.

### High Efficiency:

The high efficiency case includes pipe wrap.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Pipe Wrap (Heating) | IE_CD           | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Heating) | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

The realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Coincidence factors are set to zero since there are no electric savings for this measure.

**Impact Factors for Calculating Net Savings:**

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Pipe Wrap (Heating), Gas (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Pipe Wrap (Heating), Oil (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Pipe Wrap (Heating), Oil (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Pipe Wrap (Heating), Gas (Multifamily)   | IE_CD           | All | \$6.61             |                      |                   |                     | Varies by PA        | \$0.08                |
| Pipe Wrap (Heating), Oil (Single Family) | IE_CD           | All | \$6.61             |                      |                   |                     |                     |                       |

|                                           |       |     |        |  |  |  |  |  |
|-------------------------------------------|-------|-----|--------|--|--|--|--|--|
| Pipe Wrap (Heating),<br>Oil (Multifamily) | IE_CD | All | \$6.61 |  |  |  |  |  |
|-------------------------------------------|-------|-----|--------|--|--|--|--|--|

**Endnotes:**

**1** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.  
[CADMUS 2015 Low Income Multifamily Impact Evaluation](#)

**2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

## 2.30. HVAC - Programmable Thermostat

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-PT                               |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Installation of a programmable thermostat, which gives the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.

### BCR Measure IDs:

| Measure Name                                      | Core Initiative                              | BCR Measure ID |
|---------------------------------------------------|----------------------------------------------|----------------|
| Programmable Thermostat, Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a040        |
| Programmable Thermostat, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a041        |
| Programmable Thermostat, Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a042        |
| Programmable Thermostat, Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a043        |
| Programmable Thermostat, Electric (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a092        |
| Programmable Thermostat, Oil (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a093        |
| Programmable Thermostat, Other (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a094        |
| Programmable Thermostat, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a012        |
| Programmable Thermostat, Gas (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | GB1a034        |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed based on study results.<sup>1 2 3</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>4</sup>

| Measure Name                                      | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|---------------------------------------------------|--------------|-------------|----------------|
| Programmable Thermostat, Electric (Single Family) | 330          | 0.24        |                |
| Programmable Thermostat, Gas (Single Family)      |              |             | 2.07           |
| Programmable Thermostat, Oil (Single Family)      |              |             | 2.07           |
| Programmable Thermostat, Other (Single Family)    |              |             | 2.06           |
| Programmable Thermostat, Electric (Multifamily)   | 257          | 0.19        |                |
| Programmable Thermostat, Gas (Multifamily)        |              |             | 2.07           |
| Programmable Thermostat, Oil (Multifamily)        |              |             | 2.07           |
| Programmable Thermostat, Other (Multifamily)      |              |             | 2.06           |

### Baseline Efficiency:

The baseline efficiency case is an HVAC system without a programmable thermostat.

### High Efficiency:

The high efficiency case is an HVAC system that has a programmable thermostat installed.

### Measure Life:

The measure life is 19 years.<sup>5</sup>

| Measure Name            | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------|-----------------|-----|-----|-----|-----|-----|
| Programmable Thermostat | IE_CD           | All | 19  | n/a | n/a | 19  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Programmable Thermostat, Electric (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.43             |
| Programmable Thermostat, Gas (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Programmable Thermostat, Oil (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

|                                                 |       |     |      |      |      |      |      |      |      |
|-------------------------------------------------|-------|-----|------|------|------|------|------|------|------|
| Programmable Thermostat, Other (Single Family)  | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Programmable Thermostat, Electric (Multifamily) | IE_CD | All | 1.00 | 1.00 | n/a  | 1.00 | 1.00 | 0.00 | 0.43 |
| Programmable Thermostat, Gas (Multifamily)      | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Programmable Thermostat, Oil (Multifamily)      | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Programmable Thermostat, Other (Multifamily)    | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------|-----------------|-----|------|-----------------|------------------|------|
| Programmable Thermostat | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B. The thermostat NEI values are per household and the PAs adjust the total value by the average number of thermostats per account depending on the initiative. In the case of income eligible, we assume one thermostat per household.

| Measure Name                                      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Programmable Thermostat, Electric (Single Family) | IE_CD           | All | \$44.53            |                      | Varies by PA      | \$0.01              |                     |                       |
| Programmable Thermostat, Gas (Single Family)      | IE_CD           | All | \$44.53            |                      |                   |                     | Varies by PA        | \$0.08                |
| Programmable Thermostat, Oil (Single Family)      | IE_CD           | All | \$44.53            |                      |                   |                     |                     |                       |



|                                                 |       |     |         |  |              |        |              |        |
|-------------------------------------------------|-------|-----|---------|--|--------------|--------|--------------|--------|
| Programmable Thermostat, Other (Single Family)  | IE_CD | All | \$44.53 |  |              |        |              |        |
| Programmable Thermostat, Electric (Multifamily) | IE_CD | All | \$16.02 |  | Varies by PA | \$0.01 |              |        |
| Programmable Thermostat, Gas (Multifamily)      | IE_CD | All | \$16.02 |  |              |        | Varies by PA | \$0.08 |
| Programmable Thermostat, Oil (Multifamily)      | IE_CD | All | \$16.02 |  |              |        |              |        |
| Programmable Thermostat, Other (Multifamily)    | IE_CD | All | \$16.02 |  |              |        |              |        |

**Endnotes:**

- 
- 1** : Guidehouse Inc (2021). Residential Wi-Fi and Programmable Thermostat Impacts. [2021 Guidehouse Thermostat Impact Study](#)
- 2** : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. [2018\\_Navigant\\_HES\\_Impact\\_Evaluation](#)
- 3** : The Cadmus Group (2012). Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013. [CADMUS\\_2012\\_Multifamily\\_Impacts\\_Analysis\\_Report](#)
- 4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5** : Guidehouse (2021). Comprehensive TRM Review. [2021 Guidehouse TRM Final Report](#)
- 6** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.31. HVAC - Window AC Replacement (Retrofit)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | IE-HVAC-WACR                             |
| <b>Market</b>       | Income Eligible                          |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

### Measure Description:

Replacement of existing inefficient room air conditioners with more efficient models. This is only offered as a measure when an AC timer would not reduce usage during the peak period.

### BCR Measure IDs:

| Measure Name                          | Core Initiative                              | BCR Measure ID |
|---------------------------------------|----------------------------------------------|----------------|
| Window AC Replacement (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a051        |
| Window AC Replacement (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a116        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results except for National Grid’s multifamily measure.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                          | Core Initiative | PA                      | ΔkWh | ΔkW  |
|---------------------------------------|-----------------|-------------------------|------|------|
| Window AC Replacement (Single Family) | IE_CD           | All                     | 113  | 0.16 |
| Window AC Replacement (Multifamily)   | IE_CD           | Eversource, Unitil, CLC | 113  | 0.16 |

National Grid’s multifamily unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = (\text{Capacity}_{\text{existing}} / \text{EER}_{\text{existing}} - \text{Capacity}_{\text{new}} / \text{EER}_{\text{new}}) * \text{hours} / 1000$$

$$\Delta kW = (\text{Capacity}_{\text{existing}} / \text{EER}_{\text{existing}} - \text{Capacity}_{\text{new}} / \text{EER}_{\text{new}}) / 1000$$

Where:

Capacity<sub>existing</sub> = size of existing unit in BTUs/hour

Capacity<sub>new</sub> = size of new unit in BTUs/hour

EER<sub>existing</sub> = Energy Efficiency Ratio of base AC equipment

EER<sub>new</sub> = Energy Efficiency Ratio of new efficient AC equipment

Hours = Equivalent full load hours = 200<sup>3</sup>

**Baseline Efficiency:**

The baseline efficiency case is the existing air conditioning unit.

**High Efficiency:**

The high efficiency case is an Energy Star room air conditioning unit.

**Measure Life:**

The measure life is 9 years.<sup>4</sup>

| Measure Name                          | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Window AC Replacement (Single Family) | IE_CD           | All | 9   | n/a | n/a | 9   |
| Window AC Replacement (Multifamily)   | IE_CD           | All | 9   | n/a | n/a | 9   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Window AC Replacement (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.37             | 0.00             |
| Window AC Replacement (Multifamily)   | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.37             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                          | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Window AC Replacement (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Window AC Replacement (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                          | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Window AC Replacement (Single Family) | IE_CD           | All | \$49.50            |                      | Varies by PA      | \$0.01              |                     |                       |
| Window AC Replacement (Multifamily)   | IE_CD           | All | \$49.50            |                      | Varies by PA      | \$0.01              |                     |                       |

**Endnotes:**

- 1** : The Cadmus Group, Inc. (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 3** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 2** : RLW Analytics (2008). Coincidence Factor Study: Residential Room Air Conditioners. Prepared for Northeast Energy Efficiency Partnerships’ New England Evaluation and State Program Working Group; Page 32, Table 22 - found by averaging the EFLH values for MA states (Boston and Worcester):  $(228+172)/2 = 200$ . [RLW 2008 Coincidence Factor Study Residential Room Air Conditioners](#)
- 4** : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner. [EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Room Air Conditioner](#)
- 5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.32. Hot Water - Faucet Aerator

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-FA        |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Water Heating   |

### Measure Description:

An existing faucet aerator with a high flow rate is replaced with a new low flow aerator.

### BCR Measure IDs:

| Measure Name                             | Core Initiative                              | BCR Measure ID |
|------------------------------------------|----------------------------------------------|----------------|
| Faucet Aerator, Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a029        |
| Faucet Aerator, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a030        |
| Faucet Aerator, Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a031        |
| Faucet Aerator, Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a032        |
| Faucet Aerator, Electric (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a089        |
| Faucet Aerator, Oil (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a090        |
| Faucet Aerator, Other (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a091        |
| Faucet Aerator, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a010        |
| Faucet Aerator (Multifamily)             | Income Eligible Coordinated Delivery (IE_CD) | GB1a030        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on separate single family<sup>1</sup> and multifamily<sup>2</sup> evaluation study results. Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

| Measure Name                             | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|------------------------------------------|--------------|-------------|----------------|
| Faucet Aerator, Electric (Single Family) | 40.0         | 0.01        |                |
| Faucet Aerator, Gas (Single Family)      |              |             | 0.20           |
| Faucet Aerator, Oil (Single Family)      |              |             | 0.20           |

|                                        |      |      |      |
|----------------------------------------|------|------|------|
| Faucet Aerator, Other (Single Family)  |      |      | 0.20 |
| Faucet Aerator, Electric (Multifamily) | 62.0 | 0.02 |      |
| Faucet Aerator, Gas (Multifamily)      |      |      | 0.30 |
| Faucet Aerator, Oil (Multifamily)      |      |      | 0.30 |
| Faucet Aerator, Other (Multifamily)    |      |      | 0.30 |

**Baseline Efficiency:**

The baseline efficiency case is the existing faucet aerator with a high flow (1.3 gallons/minute).

**High Efficiency:**

The high efficiency case is a low flow faucet aerator (1 gallon/minute).

**Measure Life:**

The measure life is 7 years.<sup>4</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Faucet Aerator | IE_CD           | All | 7   | n/a | n/a | 7   |

**Other Resource Impacts:**

Residential water savings for faucet aerators in single family are 332 gallons per unit and multifamily are 708 gallons per unit.<sup>5</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Faucet Aerator, Electric | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.84             |
| Faucet Aerator, Gas      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Faucet Aerator, Oil      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Faucet Aerator, Other    | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Faucet Aerator (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Faucet Aerator (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>7</sup>

| Measure Name                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Faucet Aerator, Electric (Single Family) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |
| Faucet Aerator, Gas (Single Family)      | IE_CD           | All |                    |                      |                   |                     | Varies by PA        | \$0.08                |
| Faucet Aerator, Electric (Multifamily)   | IE_CD           | All | \$0.58             |                      | Varies by PA      | \$0.01              |                     |                       |
| Faucet Aerator, Gas (Multifamily)        | IE_CD           | All | \$0.58             |                      |                   |                     | Varies by PA        | \$0.08                |
| Faucet Aerator, Oil (Multifamily)        | IE_CD           | All | \$0.58             |                      |                   |                     |                     |                       |
| Faucet Aerator, Other (Multifamily)      | IE_CD           | All | \$0.58             |                      |                   |                     |                     |                       |

**Endnotes:**

- 
- 1 : Cadmus Group (2012). Low Income Single Family Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
  - 2 : Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
  - 3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
  - 4 : MA Common Assumptions
  - 5 : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)
  - 6 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
  - 7 : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area,

Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.  
[Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)



## 2.33. Hot Water - Heat Pump Water Heater

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-HPWH      |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Time of Sale    |
| <b>Category</b>     | Water Heating   |

### Measure Description:

Installation of a heat pump water heater (HPWH) instead of an electric resistance water heater.

### BCR Measure IDs:

| Measure Name                                              | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------------------|----------------------------------------------|----------------|
| Heat Pump Water Heaters (50 gallon) (Single Family)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a017        |
| Heat Pump Water Heaters (50 gallon) (Multifamily)         | Income Eligible Coordinated Delivery (IE_CD) | EB1a079        |
| Heat Pump Water Heater, >55 gallon (Single Family)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a280        |
| Heat Pump Water Heater displacing Oil (Single Family)     | Income Eligible Coordinated Delivery (IE_CD) | EB1a281        |
| Heat Pump Water Heater displacing Propane (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a282        |
| Heat Pump Water Heater, >55 gallon (Multifamily)          | Income Eligible Coordinated Delivery (IE_CD) | EB1a283        |
| Heat Pump Water Heater displacing Oil (Multifamily)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a284        |
| Heat Pump Water Heater displacing Propane (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a285        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results for single family.<sup>1</sup> For multifamily, savings are custom calculated.

| Measure Name                                                     | Water Heating Savings |        | Heating Savings (Penalty) |                                               | Total Savings |                 |       |                                            |
|------------------------------------------------------------------|-----------------------|--------|---------------------------|-----------------------------------------------|---------------|-----------------|-------|--------------------------------------------|
|                                                                  | ΔkWh                  | ΔMMBTU | ΔkWh                      | ΔMMBTU                                        | ΔkWh          | Max Load Factor | ΔkW   | ΔMMBTU                                     |
| Water Heater, Heat Pump, <55 gallon, Energy Star (Single Family) | 1799                  | 0      | -86.3                     | Gas = -0.50<br>Oil = -0.10<br>Propane = -0.07 | 1712          | 0.00025         | 0.43  | Gas = 0.50<br>Oil = 0.10<br>Propane = 0.07 |
| Water Heater, Heat Pump, >55 gallon, UEF 2.70 (Single Family)    | 360                   | 0      | 0                         | 0                                             | 360           | 0.00025         | 0.09  | 0                                          |
| Heat Pump Water Heater displacing Oil (Single Family)            | -1,138                | 17.4   | 0                         | 0                                             | -1,138        | 0.00025         | -0.28 | 17.4                                       |
| Heat Pump Water Heater displacing Propane (Single Family)        | -831                  | 16.4   | 0                         | 0                                             | -831          | 0.00025         | -0.21 | 16.4                                       |

### Baseline Efficiency:

The baseline efficiency case is the existing inefficient water heater.

### High Efficiency:

The high efficiency case is an electric heat pump storage water heater < 55 gallon, medium draw pattern, with an UEF of > 2.45.<sup>2</sup>

### Measure Life:

The measure life is 13 years.<sup>3</sup>

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Heat Pump Water Heater | IE_CD           | All | 13  | n/a | n/a | 13  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heat Pump Water Heater | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Coincidence factors are based on evaluation results.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------|-----------------|-----|------|-----------------|------------------|------|
| Heat Pump Water Heater | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                          | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Heat Pump Water Heater, Single Family | IE_CD           | All | \$4.64             |                      | Varies by PA      | \$0.01              |                     |                       |
| Heat Pump Water Heater, Multifamily   | IE_CD           | All | \$1.19             |                      | Varies by PA      | \$0.01              |                     |                       |

**Endnotes:**

- 1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7
- 2 : Energy Star is 2.0 UEF but no models exist that the efficiency level. Lowest available if 2.45 UEF.
- 3 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task
- 4 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task

## 2.34. Hot Water - Low-Flow Showerhead

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-S         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Water Heating   |

### Measure Description:

An existing showerhead with a high flow rate is replaced with a new low flow showerhead.

### BCR Measure IDs:

| Measure Name                                  | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------|----------------------------------------------|----------------|
| Low-Flow Showerhead, Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a025        |
| Low-Flow Showerhead, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a026        |
| Low-Flow Showerhead, Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a027        |
| Low-Flow Showerhead, Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a028        |
| Low-Flow Showerhead, Electric (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a080        |
| Low-Flow Showerhead, Oil (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a081        |
| Low-Flow Showerhead, Other (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a082        |
| Low-Flow Showerhead, Gas (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a011        |
| Low-Flow Showerhead, Gas (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | GB1a031        |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed based on study results.<sup>1 2</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>3</sup>

| Measure Name                                  | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|-----------------------------------------------|--------------|-------------|----------------|
| Low-Flow Showerhead, Electric (Single Family) | 188.0        | 0.05        |                |
| Low-Flow Showerhead, Gas (Single Family)      |              |             | 0.9            |
| Low-Flow Showerhead, Oil (Single Family)      |              |             | 1.1            |
| Low-Flow Showerhead, Other (Single Family)    |              |             | 0.9            |
| Low-Flow Showerhead, Electric (Multifamily)   | 217.0        | 0.05        |                |
| Low-Flow Showerhead, Gas (Multifamily)        |              |             | 1.07           |
| Low-Flow Showerhead, Oil (Multifamily)        |              |             | 1.07           |
| Low-Flow Showerhead, Other (Multifamily)      |              |             | 1.07           |

### Baseline Efficiency:

The baseline efficiency case is the existing showerhead with a baseline flow rate of 2.5 GPM.

### High Efficiency:

The high efficiency case is a low flow showerhead having a maximum flow rate between 1.5 and 1.7 GPM.

### Measure Life:

The measure life is 15 years.<sup>4</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead | IE_CD           | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

Water savings for Single Family are 2,401 gallons<sup>5</sup> per unit and multifamily are 1,759 gallons<sup>6</sup> per unit.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead, Electric (Single Family) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.84             |
| Low-Flow Showerhead, Gas (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Oil (Single Family)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

|                                             |       |     |      |      |      |      |      |      |      |
|---------------------------------------------|-------|-----|------|------|------|------|------|------|------|
| Low-Flow Showerhead, Other (Single Family)  | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Low-Flow Showerhead, Electric (Multifamily) | IE_CD | All | 1.00 | 1.00 | n/a  | 1.00 | 1.00 | 0.31 | 0.84 |
| Low-Flow Showerhead, Gas (Multifamily)      | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Low-Flow Showerhead, Oil (Multifamily)      | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |
| Low-Flow Showerhead, Other (Multifamily)    | IE_CD | All | 1.00 | n/a  | 1.00 | n/a  | n/a  | n/a  | n/a  |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Low-Flow Showerhead (Single Family) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Low-Flow Showerhead (Multifamily)   | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead, Electric (Single Family) | IE_CD           | All |                    | \$1.72               | Varies by PA      | \$0.01              |                     |                       |
| Low-Flow Showerhead, Gas (Single Family)      | IE_CD           | All |                    | \$1.72               |                   |                     | Varies by PA        | \$0.08                |
| Low-Flow Showerhead, Oil (Single Family)      | IE_CD           | All |                    | \$1.72               |                   |                     |                     |                       |

|                                             |       |     |        |        |              |        |              |        |
|---------------------------------------------|-------|-----|--------|--------|--------------|--------|--------------|--------|
| Low-Flow Showerhead, Other (Single Family)  | IE_CD | All |        | \$1.72 |              |        |              |        |
| Low-Flow Showerhead, Electric (Multifamily) | IE_CD | All | \$0.58 |        | Varies by PA | \$0.01 |              |        |
| Low-Flow Showerhead, Gas (Multifamily)      | IE_CD | All | \$0.58 |        |              |        | Varies by PA | \$0.08 |
| Low-Flow Showerhead, Oil (Multifamily)      | IE_CD | All | \$0.58 |        |              |        |              |        |
| Low-Flow Showerhead, Other (Multifamily)    | IE_CD | All | \$0.58 |        |              |        |              |        |

**Endnotes:**

- 1 : The Cadmus Group (2012). Low Income Single Family Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)
- 2 : The Cadmus Group (2012). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 3 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 4 : [2021 Guidehouse TRM Final Report](#)
- 5 : Staff calculations based on the methodology from The Cadmus Group, Inc. (2012). Home Energy Services Impact Evaluation.
- 6 : The Cadmus Group (2012). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 7 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.35. Hot Water - Low-Flow Showerhead with Thermostatic Valve

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-STV       |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Water Heating   |

### Measure Description:

An existing showerhead is replaced with a low-flow showerhead with an integrated thermostatic shut-off valve (TSV).

### BCR Measure IDs:

| <b>Measure Name</b>                                  | <b>Core Initiative</b>                       | <b>BCR Measure ID</b> |
|------------------------------------------------------|----------------------------------------------|-----------------------|
| Low-Flow Showerhead with TSV, Electric (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a083               |
| Low-Flow Showerhead with TSV, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a084               |
| Low-Flow Showerhead with TSV, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a085               |
| Low-Flow Showerhead with TSV, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a032               |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| <b>Measure Name</b>                                  | <b>ΔkWh</b> | <b>ΔkW</b> | <b>ΔMMBtu</b> |
|------------------------------------------------------|-------------|------------|---------------|
| Low-Flow Showerhead with TSV, Electric (Multifamily) | 335         | 0.08       |               |
| Low-Flow Showerhead with TSV, Gas (Multifamily)      |             |            | 1.9           |
| Low-Flow Showerhead with TSV, Oil (Multifamily)      |             |            | 1.7           |
| Low-Flow Showerhead with TSV, Other (Multifamily)    |             |            | 1.7           |



**Baseline Efficiency:**

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

**High Efficiency:**

The high efficiency case is a low-flow showerhead (1.5 GPM) with integrated thermostatically actuated valve.

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead with TSV (Multifamily) | IE_CD           | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

Water savings is 2,723 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead with TSV, Electric (Multifamily) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.84             |
| Low-Flow Showerhead with TSV, Gas (Multifamily)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead with TSV, Oil (Multifamily)      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead with TSV, Other (Multifamily)    | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Low-Flow Showerhead with TSV (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead with TSV, Electric (Multifamily) | IE_CD           | All | \$0.58             |                      | Varies by PA      | \$0.01              |                     |                       |
| Low-Flow Showerhead with TSV, Gas (Multifamily)      | IE_CD           | All | \$0.58             |                      |                   |                     | Varies by PA        | \$0.08                |
| Low-Flow Showerhead with TSV, Oil (Multifamily)      | IE_CD           | All | \$0.58             |                      |                   |                     |                     |                       |
| Low-Flow Showerhead with TSV, Other (Multifamily)    | IE_CD           | All | \$0.58             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : [2021 Guidehouse TRM Final Report](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : [2021 Guidehouse TRM Final Report](#)
- 4 : National\_Grid\_2014\_ShowerStart\_Savings\_Final\_2015-2-9  
[National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 5 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)

## 2.36. Hot Water - Pipe Wrap (Water Heating)

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-PW        |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Water Heating   |

### Measure Description:

Installation of DHW pipe wraps.

### BCR Measure IDs:

| Measure Name                                        | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------------|----------------------------------------------|----------------|
| Pipe Wrap (Water Heating), Electric (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a022        |
| Pipe Wrap (Water Heating), Oil (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a023        |
| Pipe Wrap (Water Heating), Other (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a024        |
| Pipe Wrap (Water Heating), Electric (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | EB1a070        |
| Pipe Wrap (Water Heating), Oil (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a071        |
| Pipe Wrap (Water Heating), Other (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a072        |
| Pipe Wrap, Gas (Water Heating) (Single Family)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a009        |
| Pipe Wrap (Water Heating) (Multifamily)             | Income Eligible Coordinated Delivery (IE_CD) | GB1a025        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results where unit is a household with pipe wrap installed on hot water pipes.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                                        | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|-----------------------------------------------------|--------------|-------------|----------------|
| Pipe Wrap (Water Heating), Electric (Single Family) | 41           | 0.01        |                |
| Pipe Wrap (Water Heating), Electric (Single Family) | 129          | 0.03        |                |
| Pipe Wrap (Water Heating), Gas                      |              |             | 0.40           |
| Pipe Wrap (Water Heating), Oil                      |              |             | 0.40           |
| Pipe Wrap (Water Heating), Other                    |              |             | 0.40           |

**Baseline Efficiency:**

The baseline efficiency case is the existing hot water equipment.

**High Efficiency:**

The high efficiency case includes pipe wrap.

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name              | PA  | Core Initiative | EUL | OYF | RUL | AML |
|---------------------------|-----|-----------------|-----|-----|-----|-----|
| Pipe Wrap (Water Heating) | All | IE_CD           | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Water Heating), Electric | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.81             |
| Pipe Wrap (Water Heating), Gas      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Oil      | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Other    | IE_CD           | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

The realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

| PA  | Measure Name              | Core Initiative | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----|---------------------------|-----------------|------|-----------------|------------------|------|
| All | Pipe Wrap (Water Heating) | IE_CD           | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Pipe Wrap (Water Heating), Electric (Single Family) | IE_CD           | All | \$48.94            |                      | Varies by PA      | \$0.01              |                     |                       |
| Pipe Wrap (Water Heating), Gas (Single Family)      | IE_CD           | All | \$48.94            |                      |                   |                     | Varies by PA        | \$0.08                |
| Pipe Wrap (Water Heating), Oil (Single Family)      | IE_CD           | All | \$48.94            |                      |                   |                     |                     |                       |
| Pipe Wrap (Water Heating), Other (Single Family)    | IE_CD           | All | \$48.94            |                      |                   |                     |                     |                       |
| Pipe Wrap (Water Heating), Electric (Multifamily)   | IE_CD           | All | \$6.61             |                      | Varies by PA      | \$0.01              |                     |                       |
| Pipe Wrap (Water Heating), Gas (Multifamily)        | IE_CD           | All | \$6.61             |                      |                   |                     | Varies by PA        | \$0.08                |
| Pipe Wrap (Water Heating), Oil (Multifamily)        | IE_CD           | All | \$6.61             |                      |                   |                     |                     |                       |
| Pipe Wrap (Water Heating), Other (Multifamily)      | IE_CD           | All | \$6.61             |                      |                   |                     |                     |                       |

**Endnotes:**

**1** : Cadmus Group (2012). Massachusetts Low Income Single Family Program Impact Evaluation. [CADMUS 2012 Single Family Low Income Impact Eval](#)

**2** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**3** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial and HVAC Measures. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

## 2.37. Hot Water - Solar Hot Water

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | IE-S-HW           |
| <b>Market</b>       | Income Eligible   |
| <b>Program Type</b> | Early Replacement |
| <b>Category</b>     | Other             |

### Measure Description:

Installation of Solar Hot Water in a residence with existing electric hot water.

### BCR Measure IDs:

| Measure                         | Core Initiative                              | BCR Measure ID |
|---------------------------------|----------------------------------------------|----------------|
| Solar Hot Water (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | EB1a279        |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = [WHkwh\_base] - [(HWHDkwh) * (1 - \%SHWdesign)] / (\%WHsupp)]$$

Where

WHkwh\_base = Federal standards for maximum allowable energy consumption.

HWHDkwh = The total household water heating demand in kWh.

%SHWdesign = The design percent of household water heating demand met by the solar hot water system.

%WHsupp = The efficiency of the supplemental hot water system for household water heating demand not met by the solar hot water system.

### Baseline Efficiency:

$$WHkwh\_base = (365 \text{ days/year}) * (0.000293071 \text{ kWh/BTU}) * (V) * (\rho) * (Cp) * (\Delta T) / UEF$$

Where

V = Volume of hot water drawn based on draw pattern (Gallon), where V = 10 for the very-small-usage draw pattern, V = 38 for the low-usage draw pattern, V = 55 for the medium-usage draw pattern, V = 84 for high-usage draw pattern

$\rho$  = Water density (lb/gallon) = 8.24

Cp = Specific heat of water (Btu/lb) = 1

$\Delta T$  = Difference between inlet and outlet temp ( $\Delta T$ ) = 67

UEF = Uniform Energy Factor (see table below)

Electric Storage Water Heater Conservation Standards<sup>1</sup>

Where:

Vr = Rated Storage Volume (Gallon)

| Rated Storage Volume | Draw Pattern | Uniform Energy Factor |
|----------------------|--------------|-----------------------|
| <20                  | Very Small   | 0.7836 - (0.0013 xVr) |
|                      | Low          | 0.8939 - (0.0008 xVr) |
|                      | Medium       | 0.9112 - (0.0007 xVr) |
|                      | High         | 0.9255 - (0.0006 xVr) |
| ≥20 and ≤55          | Very Small   | 0.8808 - (0.0008 xVr) |
|                      | Low          | 0.9254 - (0.0003 xVr) |
|                      | Medium       | 0.9307 - (0.0002 xVr) |
|                      | High         | 0.9349 - (0.0001 xVr) |
| >55 and ≤120         | Very Small   | 1.9236 - (0.0011 xVr) |
|                      | Low          | 2.0440 - (0.0011 xVr) |
|                      | Medium       | 2.1171 - (0.0011 xVr) |
|                      | High         | 2.2418 - (0.0011 xVr) |
| >120                 | Very Small   | 0.6802 - (0.0003 xVr) |
|                      | Low          | 0.8620 - (0.0006 xVr) |
|                      | Medium       | 0.9042 - (0.0007 xVr) |
|                      | High         | 0.9437 - (0.0007 xVr) |

**High Efficiency:**

The new system is a solar hot water heater paired with a supplemental electric water heating source.

**Measure Life:**

The measure life for a new solar hot water system is 20 years.<sup>2</sup>

| Measure Name    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|-----|
| Solar Hot Water | IE_CD           | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.



**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Solar Hot Water | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.81             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% until an evaluation occurs.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values have not been studied. The default NTG is 1.00.

| Measure Name    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------|-----------------|-----|------|-----------------|------------------|------|
| Solar Hot Water | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified with this measure.

**Endnotes:**

**1** : <https://www.federalregister.gov/documents/2020/05/21/2020-10564/energy-conservation-program-energy-conservation-standards-for-consumer-water-heaters>

## 2.38. Hot Water - Thermostatic Valve

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-TV        |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Water Heating   |

### Measure Description:

A stand-alone valve that may be used with existing showerhead. Thermostatic shut-off valve technology is known by the trademarked name ShowerStart™.

### BCR Measure IDs:

| Measure Name                                        | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------------|----------------------------------------------|----------------|
| Thermostatic Shut-off Valve, Electric (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a086        |
| Thermostatic Shut-off Valve, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a087        |
| Thermostatic Shut-off Valve, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a088        |
| Thermostatic Shut-off Valve, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a033        |

### Algorithms for Calculating Primary Energy Impact:

The unit kWh and MMBtu savings are deemed based on engineering analysis.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                                        | ΔkWh | ΔkW  | Δ MMBtu |
|-----------------------------------------------------|------|------|---------|
| Thermostatic Shut-off Valve, Electric (Multifamily) | 69   | 0.02 |         |
| Thermostatic Shut-off Valve, Gas (Multifamily)      |      |      | 0.34    |
| Thermostatic Shut-off Valve, Oil (Multifamily)      |      |      | 0.39    |
| Thermostatic Shut-off Valve, Other (Multifamily)    |      |      | 0.34    |

**Baseline Efficiency:**

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

**High Efficiency:**

The high efficiency case is a standard-flow showerhead (2.5 GPM) with the addition of the stand-alone thermostatic shut-off valve (the “Ladybug”).

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                              | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Thermostatic Shut-off Valve (Multifamily) | IE_CD           | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

Water savings are 558 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Thermostatic Shut-off Valve, Electric (Multifamily) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.84             |
| Thermostatic Shut-off Valve, Gas (Multifamily)      | IE_CD           | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Oil (Multifamily)      | IE_CD           | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Other (Multifamily)    | IE_CD           | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Thermostatic Shutoff Valve (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Thermostatic Shut-off Valve, Electric (Multifamily) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |
| Thermostatic Shut-off Valve, Gas (Multifamily)      | IE_CD           | All |                    |                      |                   |                     | Varies by PA        | \$0.08                |
| Thermostatic Shut-off Valve, Oil (Multifamily)      | IE_CD           | All |                    |                      |                   |                     |                     |                       |
| Thermostatic Shut-off Valve, Other (Multifamily)    | IE_CD           | All |                    |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : National Grid (2014). Review of ShowerStart evolve. [National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : [2021 Guidehouse TRM Final Report](#)
- 4 : National Grid (2014). Review of ShowerStart evolve. [National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 5 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

## 2.39. Hot Water - Water Heating System

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-WH-WHS       |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Water Heating   |

### Measure Description:

Installation of high efficiency water heating equipment to replace the existing inefficient water heater.

### BCR Measure IDs:

| Measure Name                                  | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------|----------------------------------------------|----------------|
| Tankless Water Heater, Oil (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | EB1a074        |
| Tankless Water Heater, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a075        |
| Indirect Water Heater, Other (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a076        |
| Standalone Water Heater, Oil (Multifamily)    | Income Eligible Coordinated Delivery (IE_CD) | EB1a077        |
| Standalone Water Heater, Other (Multifamily)  | Income Eligible Coordinated Delivery (IE_CD) | EB1a078        |
| Indirect Water Heater, Gas (Single Family)    | Income Eligible Coordinated Delivery (IE_CD) | GB1a054        |
| Stand Alone Water Heater, Gas (Single Family) | Income Eligible Coordinated Delivery (IE_CD) | GB1a055        |
| On Demand Water Heater, Gas (Multifamily)     | Income Eligible Coordinated Delivery (IE_CD) | GB1a027        |
| Indirect Water Heater, Gas (Multifamily)      | Income Eligible Coordinated Delivery (IE_CD) | GB1a028        |
| Stand Alone Water Heater, Gas (Multifamily)   | Income Eligible Coordinated Delivery (IE_CD) | GB1a029        |

### Algorithms for Calculating Primary Energy Impact:

Eversource:

The program delivery agency uses vendor calculated energy savings for all allowed measures. These savings values are calculated with custom building simulation model software where the user inputs a set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to “adding” individual measure results.

**All PAs except Eversource:**

$$\text{MMBtu} = \text{Units} \times 18\text{MMBtu/unit} \times (1/\text{EF}_{\text{BASE}}) - (1/\text{EF}_{\text{EE}})$$

Where:

Unit = Total number of dwelling units utilizing the water heater

18 MMBtu/Unit = Average annual water heating energy demand per dwelling unit <sup>1</sup>

EF<sub>BASE</sub> = Energy Factor for the baseline water heater

EF<sub>EE</sub> = Energy Factor for the new efficient water heater

**Baseline Efficiency:**

The baseline efficiency case is a stand-alone tank water heater is an existing 0.58 UEF standalone water heater.<sup>2</sup>

**High Efficiency:**

The high efficiency case is a stand-alone storage water heater with an energy factor >= 0.66.<sup>3</sup>

**Measure Life:**

| Measure Name                    | Core Initiative | PA  | EUL             | OYF | RUL | AML |
|---------------------------------|-----------------|-----|-----------------|-----|-----|-----|
| Indirect Water Heater           | IE_CD           | All | 20 <sup>2</sup> | n/a | n/a | 20  |
| Stand Alone Water Heater        | IE_CD           | All | 13 <sup>3</sup> | n/a | n/a | 13  |
| On Demand/Tankless Water Heater | IE_CD           | All | 20 <sup>4</sup> | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                      | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Water Heater, Gas (Multifamily)   | IE_CD           | Berkshire     | 1.00 | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Gas (Multifamily)   | IE_CD           | Columbia      | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Gas (Multifamily)   | IE_CD           | Eversource    | 1.00 | n/a             | 1.05             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Gas (Multifamily)   | IE_CD           | Liberty       | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Gas (Multifamily)   | IE_CD           | National Grid | 1.00 | n/a             | 0.75             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Gas (Multifamily)   | IE_CD           | Unitil        | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Oil (Multifamily)   | IE_CD           | All           | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Water Heater, Other (Multifamily) | IE_CD           | All           | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

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

**Realization Rates:**

Realization rates are based on evaluation results.<sup>5</sup>

**Coincidence Factors:**

There are no electric savings for this measure.

**Impact Factors for Calculating Net Savings:**

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Water Heater | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Stand Alone Water Heater (Single Family) | IE_CD           | All | \$1.30             |                      |                   |                     | Varies by PA        | \$0.08                |
| Indirect Water Heater (Single Family)    | IE_CD           | All | \$0.70             |                      |                   |                     | Varies by PA        | \$0.08                |
| Water Heater, Gas (Multifamily)          | IE_CD           | All | \$1.19             |                      |                   |                     | Varies by PA        | \$0.08                |
| Water Heater, Oil/Other (Multifamily)    | IE_CD           | All | \$1.19             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1** : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 2** : This is the weighted average baseline UEF of the medium and high draw units based in 2016-2017 rebated units. [2021 Guidehouse TRM Final Report](#)
- 3** : This is the weighted average efficient UEF of the medium and high draw units based in 2016-2017 rebated units. [2021 Guidehouse TRM Final Report](#)
- 2** : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 3** : DOE (2008). ENERGY STAR® Residential Water Heaters: Final Criteria Analysis. Prepared for the DOE; Page 10. [DOE 2008 ENERGY STAR Residential Water Heaters Final Criteria Analysis](#)
- 4** : DOE (2008). ENERGY STAR® Residential Water Heaters: Final Criteria Analysis. Prepared for the DOE; Page 10. [DOE 2008 ENERGY STAR Residential Water Heaters Final Criteria Analysis](#)
- 5** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)



## 2.40. Lighting - Income Eligible

|                     |                                              |
|---------------------|----------------------------------------------|
| <b>Measure Code</b> | IE-L-LEDB                                    |
| <b>Market</b>       | Income Eligible                              |
| <b>Program Type</b> | Lost Opportunity, New Construction, Retrofit |
| <b>Category</b>     | Lighting                                     |

### Measure Description:

The installation of Light-Emitting Diode (LED) bulbs and fixtures. LEDs offer comparable luminosity to incandescent and halogen bulbs at significantly less wattage and significantly longer lamp lifetimes.

### BCR Measure IDs:

| Measure Name                                         | Core Initiative                              | BCR Measure ID |
|------------------------------------------------------|----------------------------------------------|----------------|
| LED Bulb (Single Family)                             | Income Eligible Coordinated Delivery (IE_CD) | EB1a033        |
| LED Bulb (Specialty) (Single Family)                 | Income Eligible Coordinated Delivery (IE_CD) | EB1a034        |
| LED Bulb (Reflectors) (Single Family)                | Income Eligible Coordinated Delivery (IE_CD) | EB1a035        |
| LED Bulb (Multifamily)                               | Income Eligible Coordinated Delivery (IE_CD) | EB1a103        |
| LED Bulb (Specialty) (Multifamily)                   | Income Eligible Coordinated Delivery (IE_CD) | EB1a104        |
| LED Bulb (Reflectors) (Multifamily)                  | Income Eligible Coordinated Delivery (IE_CD) | EB1a105        |
| LED Bulb, Common Area (Multifamily)                  | Income Eligible Coordinated Delivery (IE_CD) | EB1a108        |
| Indoor Fixture (Single Family)                       | Income Eligible Coordinated Delivery (IE_CD) | EB1a036        |
| LED Fixture, Indoor In Unit (Multifamily)            | Income Eligible Coordinated Delivery (IE_CD) | EB1a107        |
| LED Fixture, Outdoor In Unit (Multifamily)           | Income Eligible Coordinated Delivery (IE_CD) | EB1a106        |
| LED Fixture, Indoor Common Area (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a109        |
| LED Fixture, Linear Indoor Common Area (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a110        |
| LED Fixture, Outdoor Common Area (Multifamily)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a111        |

## Algorithms for Calculating Primary Energy Impact:

### Factors for Calculating Savings for Residential Lighting

Delta watts<sup>1</sup> and hours of use<sup>2 3</sup> noted in the table below for deemed measures are based on evaluation results. For vendor-calculated measures, delta watts are based on verification of pre-installation wattage, and hours of use are input by the vendor based on space type. For common area measures in multifamily buildings (labeled Attached Low Rise, High Rise, and Residential End Use), vendors reference the hours recommended in the Navigant Multifamily Impact Study<sup>4</sup>(see table below). For Income Eligible In-Unit Fixtures, vendors reference the 2014 Northeast HOU Study (see table below).<sup>5</sup> For Income Eligible common area measures, vendors calculate the hours based on site conditions.

Savings are then calculated per the algorithm below.

$$\Delta kWh = ((QTY_{PRE} \times Watt_{SPRE}) - (QTY_{EE} \times Watt_{SEE}) \times \text{Hours}) / 1000$$

$$\Delta kW = \Delta kWh \times kW/kWh$$

Where:

QTY<sub>PRE</sub> = Quantity of pre-retrofit fixtures/bulbs

QTY<sub>EE</sub> = Quantity of efficient fixtures/bulbs installed

Watts<sub>PRE</sub> = Rated watts of pre-retrofit fixtures/bulbs

Watts<sub>EE</sub> = Rated watts of efficient fixtures/bulbs installed

Hours = Annual hours of operation for pre-retrofit case. Note that any reduction in hours of operation due to the addition of lighting controls are calculated separately; refer to the relevant TRM entry.

kW/kWh = Average kW reduction per kWh reduction: 0.00025 kW/kWh<sup>6</sup>

| Measure Name                          | Core Initiative | Δ Watts      | Annual HOU           | # of Bulbs | ΔKWh              | ΔkW        |
|---------------------------------------|-----------------|--------------|----------------------|------------|-------------------|------------|
| LED Bulb (Single Family)              | IE_CD           | 43           | 949                  | 1          | 40.8              | 0.01       |
| LED Bulb (Specialty) (Single Family)  | IE_CD           | 36           | 949                  | 1          | 34.2              | 0.01       |
| LED Bulb (Reflectors) (Single Family) | IE_CD           | 45           | 949                  | 1          | 42.7              | 0.01       |
| LED Bulb (Multifamily)                | IE_CD           | 43           | 949                  | 1          | 40.8              | 0.01       |
| LED Bulb (Specialty) (Multifamily)    | IE_CD           | 36           | 949                  | 1          | 34.2              | 0.01       |
| LED Bulb (Reflectors) (Multifamily)   | IE_CD           | 45           | 949                  | 1          | 42.7              | 0.1        |
| LED Bulb, Common Area (Multifamily)   | IE_CD           | Vendor Input | Varies by Space Type | N/A        | Vendor Calculated | Calculated |
| Indoor Fixture (Single Family)        | IE_CD           |              |                      |            | 62                | 0.02       |

|                                                      |       |             |      |             |             |            |
|------------------------------------------------------|-------|-------------|------|-------------|-------------|------------|
| LED Fixture, Indoor In Unit (Multifamily)            | IE_CD | 37.63       | 803  | 1.49        | 41          | 0.01       |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD | 37.63       | 803  | 2           | 55          | 0.01       |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |

**Income-Eligible In-Unit Fixture HOU**

| Space Type   | Annual HOU |
|--------------|------------|
| Bedroom      | 730        |
| Bathroom     | 657        |
| Kitchen      | 1,460      |
| Living Space | 1,205      |
| Dining Room  | 986        |
| Exterior     | 2,008      |
| Other        | 621        |

**Baseline Efficiency:**

The baseline efficiency case for Income Eligible Coordinated Delivery in-unit bulbs is a combination of an incandescent bulb and halogen bulb. The baseline efficiency case for In-Unit Fixtures and all Common Area bulbs and fixtures is the existing site conditions, as identified by the vendor.

**High Efficiency:**

The high efficiency case is an LED.

**Measure Life:**

The table below includes the Expected Useful Life (amount of time the LED is physically expected to last) and Adjusted Measure Life (the amount of time that the PAs claim savings). EULs for bulbs are based on a rated lifetime of 15,000 hours, per ENERGY STAR specifications. EULs for Common Area Fixtures are based on the following rated lives: Indoor - 55,000 hours; Linear - 75,000 hours; Exterior - 50,000 hours. AMLs for in-unit bulbs were derived via a consensus process with DOER. AMLs for Common Area lighting utilize

| Measure Name                                         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| LED Bulb (Single Family)                             | IE_CD           | All | 15  | n/a | n/a | 1   |
| LED Bulb (Multi Family)                              | IE_CD           |     |     |     |     |     |
| LED Bulb, Reflector (Single Family)                  | IE_CD           | All | 15  | n/a | n/a | 1   |
| LED Bulb, Reflector (Multi Family)                   | IE_CD           |     |     |     |     |     |
| LED Bulb, Specialty (Single Family)                  | IE_CD           | All | 15  | n/a | n/a | 1   |
| LED Bulb, Specialty (Multi Family)                   | IE_CD           |     |     |     |     |     |
| LED Bulb, Common Area (Multifamily)                  | IE_CD           | All | 3   | n/a | n/a | 1   |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | All | 20  | n/a | n/a | 5   |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | All | 6   | n/a | n/a | 6   |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | All | 8   | n/a | n/a | 8   |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD           | All | 11  | n/a | n/a | 11  |
| Indoor Fixture (Single Family)                       | IE_CD           | All | 20  | n/a | n/a | 9   |

**Other Resource Impacts:**

There are no other resource impacts. Interactive effects for direct install lighting are assumed to be captured in the realization rates for insulation measures within the same program.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| LED Bulb (Single Family)                             | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.55             | 0.85             |
| LED Bulb (Specialty) (Single Family)                 |                 |     |      |                 |                  |                  |                  |                  |                  |
| LED Bulb (Reflectors) (Single Family)                |                 |     |      |                 |                  |                  |                  |                  |                  |
| LED Bulb (Multifamily)                               |                 |     |      |                 |                  |                  |                  |                  |                  |
| LED Bulb (Specialty) (Multifamily)                   |                 |     |      |                 |                  |                  |                  |                  |                  |
| LED Bulb (Reflectors) (Multifamily)                  |                 |     |      |                 |                  |                  |                  |                  |                  |
| LED Bulb, Common Area (Multifamily)                  | IE_CD           | All | 1.00 | Varies by PA    | Varies by PA     | Varies by PA     | Varies by PA     | 0.80             | 0.61             |
| Indoor Fixture (Single Family)                       | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.19             | 0.35             |
| LED Fixture, Indoor In Unit (Multifamily)            | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.19             | 0.35             |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.19             | 0.35             |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | All | 1.00 | PA Specific     | PA Specific      | PA Specific      | PA Specific      | 0.34             | 0.30             |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | All | 1.00 | PA Specific     | PA Specific      | PA Specific      | PA Specific      | 0.34             | 0.30             |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD           | All | 1.00 | PA Specific     | PA Specific      | PA Specific      | PA Specific      | 0.19             | 0.20             |

**In-Service Rate:**

Residential Coordinated Delivery high rise ISRs are based on evaluation.<sup>9</sup> All other Direct Install ISRs are assumed to be 100%.

**Realization Rates:**

Realization rates for Multifamily Common Area Lighting in Income Eligible Coordinated Delivery are PA specific and based on evaluation.<sup>10</sup>

Realization rates for Income Eligible In-Unit lighting and non-income-eligible Common Area lighting are also 100% as vendors are using deemed HOU by space type.<sup>11</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for Residential Coordinated Delivery are from the "Massachusetts Residential Programs Net-to-Gross Research of RCD and Select Products Measures" evaluation.<sup>16</sup>

| Measure Name                                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| LED Bulb (Single Family)                             |                 |     |      |                 |                  |      |
| LED Bulb (Multifamily)                               |                 |     |      |                 |                  |      |
| LED Bulb (Specialty) (Single Family)                 |                 |     |      |                 |                  |      |
| LED Bulb (Specialty) (Multifamily)                   | IE_CD           | All | 0.0  | 0.0             | 0.0              | 1.0  |
| LED Bulb (Reflectors) (Single Family)                |                 |     |      |                 |                  |      |
| LED Bulb (Reflectors) (Multifamily)                  |                 |     |      |                 |                  |      |
| LED Bulb, Common Area (Multifamily)                  |                 |     |      |                 |                  |      |
| Indoor Fixture (Single Family)                       | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Indoor In Unit (Multifamily)            | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                                                                                                                                                                                                     | Core Initiative | PA  | Annual \$ per Unit                                                                                       | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh             | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----|----------------------------------------------------------------------------------------------------------|----------------------|-------------------|---------------------------------|---------------------|-----------------------|
| LED Bulb (Single Family)<br><br>LED Bulb (Multifamily)<br><br>LED Bulb (Specialty) (Single Family)<br>LED Bulb (Specialty) (Multifamily)<br><br>LED Bulb (Reflectors) (Single Family)<br><br>LED Bulb (Reflectors) (Multifamily) | IE_CD           | All |                                                                                                          |                      |                   | Rate Discount NEI; Varies by PA | \$0.005             |                       |
| LED Bulb, Common Area (Multifamily)                                                                                                                                                                                              | IE_CD           | All | \$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit. |                      |                   | Rate Discount NEI; Varies by PA | \$0.005             |                       |
| Indoor Fixture (Single Family)                                                                                                                                                                                                   | IE_CD           | All |                                                                                                          |                      |                   | Rate Discount NEI; Varies by PA | \$0.01              |                       |
| LED Fixture, Indoor In Unit (Multifamily)                                                                                                                                                                                        | IE_CD           | All |                                                                                                          |                      |                   | Rate Discount NEI; Varies by PA | \$0.01              |                       |
| LED Fixture, Outdoor In Unit (Multifamily)                                                                                                                                                                                       | IE_CD           | All |                                                                                                          |                      |                   | Rate Discount NEI;              | \$0.01              |                       |

|                                                      |       |     |                                                                                                          |  |                                 |        |  |  |
|------------------------------------------------------|-------|-----|----------------------------------------------------------------------------------------------------------|--|---------------------------------|--------|--|--|
|                                                      |       |     |                                                                                                          |  | Varies by PA                    |        |  |  |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD | All | \$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit. |  | Rate Discount NEI; Varies by PA | \$0.01 |  |  |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD | All | \$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit. |  | Rate Discount NEI; Varies by PA | \$0.01 |  |  |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD | All | \$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit. |  | Rate Discount NEI; Varies by PA | \$0.01 |  |  |

**Endnotes:**

- 1** : NMR Group, Inc. (2020). Delta Watt Update (MA19R09-E). [2019 NMR DeltaWattReport](#)
- 2** : NMR Group, Inc. (2020). Residential Lighting Hours-of-Use Quick Hit Study (MA20R21-E). [2019 NMR LightingHOU Update](#)
- 3** : Navigant (2017). Multifamily Program Improvement Strategies (RES42). [Navigant 2017 MF Program Improvement Strategies Prelim Results](#)
- 4** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 5** : NMR Group, Inc. (2014). Northeast Residential Hours of Use Study. [NMR 2014 Northeast Residential Lighting HOU](#)
- 6** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 9** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 10** : Cadmus (2015). Low Income Multifamily Impact Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 11** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 16** : Guidehouse (2021). Massachusetts Residential Programs Net-to-Gross Research of RCD and Select Products Measures. [2021 Guidehouse MA Res NTG Final Report](#)



## 2.41. Lighting - LED Fixture

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-L-F          |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Lighting        |

### Measure Description:

Replacement of existing inefficient fixtures with the installation of new efficient fixtures.

### BCR Measure IDs:

| Measure                                              | Core Initiative                              | BCR Measure ID |
|------------------------------------------------------|----------------------------------------------|----------------|
| Indoor Fixture (Single Family)                       | Income Eligible Coordinated Delivery (IE_CD) | EB1a036        |
| LED Fixture, Indoor In Unit (Multifamily)            | Income Eligible Coordinated Delivery (IE_CD) | EB1a107        |
| LED Fixture, Outdoor In Unit (Multifamily)           | Income Eligible Coordinated Delivery (IE_CD) | EB1a106        |
| LED Fixture, Indoor Common Area (Multifamily)        | Income Eligible Coordinated Delivery (IE_CD) | EB1a109        |
| LED Fixture, Linear Indoor Common Area (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a110        |
| LED Fixture, Outdoor Common Area (Multifamily)       | Income Eligible Coordinated Delivery (IE_CD) | EB1a111        |

### Algorithms for Calculating Primary Energy Impact:

Vendor calculated unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \text{Hours}_{\text{PRE}} * ((\text{QTY}_{\text{PRE}} \times \text{Watts}_{\text{PRE}}) - (\text{QTY}_{\text{EE}} \times \text{Watts}_{\text{SEE}})) / 1000$$

$$\Delta kW = \Delta kWh \times kW/kWh$$

Where:

QTY<sub>PRE</sub> = Quantity of pre-retrofit fixtures/bulbs

QTY<sub>EE</sub> = Quantity of efficient fixtures/bulbs installed

Watts<sub>PRE</sub> = Rated watts of pre-retrofit fixtures/bulbs

Watts<sub>SEE</sub> = Rated watts of efficient fixtures/bulbs installed

Hours<sub>PRE</sub> = Annual hours of operation for pre-retrofit case lighting fixtures. Note that any reduction in hours of operation due to the addition of lighting controls are calculated separately; refer to that TRM entry.

kW/kWh = Average kW reduction per kWh reduction: 0.00030 kW/kWh<sup>1</sup>

Annual hours of use for Residential Coordinated Delivery are based on evaluation results.<sup>2 3 4</sup> Annual hours of use for Income Eligible in-unit fixtures are deemed based on the space type -- see table below.<sup>5</sup> Annual hours of use for Income Eligible common area fixtures are determined on a site-by-site basis by the vendor.

| Measure Name                                         | Core Initiative | Δ Watts     | HOU  | # of Bulbs  | ΔKWh        | ΔkW        |
|------------------------------------------------------|-----------------|-------------|------|-------------|-------------|------------|
| Indoor Fixture (Single Family)                       | IE_CD           |             |      |             | 62          | 0.02       |
| LED Fixture, Indoor In Unit (Multifamily)            | IE_CD           | 37.63       | 803  | 1.49        | 41          | 0.01       |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | 37.63       | 803  | 2           | 55          | 0.01       |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD           | Vendor Calc | 6388 | Vendor Calc | Vendor Calc | Calculated |

| In-Unit Space Type | Annual Hours of Use (HOU) |
|--------------------|---------------------------|
| Bedroom            | 730                       |
| Bathroom           | 657                       |
| Kitchen            | 1,460                     |
| Living Space       | 1,205                     |
| Dining Room        | 986                       |
| Exterior           | 2,008                     |
| Other              | 621                       |

**Baseline Efficiency:**

The baseline efficiency case for Residential Coordinated Delivery and Income Eligible Coordinated Delivery is the existing fixture on site, as identified by the vendor.

### High Efficiency:

The high efficiency case is an ENERGY STAR® rated LED fixture.

### Measure Life:

The tables below include the EUL and AML for LED Fixtures.<sup>9</sup>

| Measure Name                                         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | All | 20  | n/a | n/a | 5   |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | All | 6   | n/a | n/a | 6   |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | All | 8   | n/a | n/a | 8   |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD           | All | 11  | n/a | n/a | 11  |
| Indoor Fixture (Single Family)                       | IE_CD           | All | 20  | n/a | n/a | 9   |

### Other Resource Impacts:

There are no other resource impacts. Interactive effects for direct install lighting are assumed to be captured in the realization rates for insulation measures within the same program.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Indoor Fixture (Single Family)                       | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.19             | 0.35             |
| LED Fixture, Indoor In Unit (Multifamily)            | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.19             | 0.35             |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | All | 1.00 | 1.01            | 1.00             | 1.20             | 0.93             | 0.19             | 0.35             |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | All | 1.00 | PA Specific     | PA Specific      | PA Specific      | PA Specific      | 0.34             | 0.30             |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | All | 1.00 | PA Specific     | PA Specific      | PA Specific      | PA Specific      | 0.34             | 0.30             |

|                                                |       |     |      |             |             |             |             |      |      |
|------------------------------------------------|-------|-----|------|-------------|-------------|-------------|-------------|------|------|
| LED Fixture, Outdoor Common Area (Multifamily) | IE_CD | All | 1.00 | PA Specific | PA Specific | PA Specific | PA Specific | 0.19 | 0.20 |
|------------------------------------------------|-------|-----|------|-------------|-------------|-------------|-------------|------|------|

**In-Service Rate:**

Residential Coordinated Delivery high rise LED fixture ISRs are from the Navigant evaluation report.<sup>11</sup>

**Realization Rates:**

The realization rate for Multifamily Common Area lighting in Income Eligible Coordinated Delivery are PA specific and come from the 2015 Cadmus Low-Income Multifamily evaluation report.<sup>12</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>13</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for Residential Coordinated Delivery high rise and common area LED Fixtures are from the Navigant Multi-Family evaluation.<sup>16</sup>

| Measure Name                                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Indoor Fixture (Single Family)                       | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Indoor In Unit (Multifamily)            | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Indoor Fixture (Single Family)            | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |
| LED Fixture, Indoor In Unit (Multifamily) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |

|                                                      |       |     |          |  |              |        |  |  |
|------------------------------------------------------|-------|-----|----------|--|--------------|--------|--|--|
| LED Fixture, Outdoor In Unit (Multifamily)           | IE_CD | All |          |  | Varies by PA | \$0.01 |  |  |
| LED Fixture, Indoor Common Area (Multifamily)        | IE_CD | All | \$109.20 |  | Varies by PA | \$0.01 |  |  |
| LED Fixture, Linear Indoor Common Area (Multifamily) | IE_CD | All | \$109.20 |  | Varies by PA | \$0.01 |  |  |
| LED Fixture, Outdoor Common Area (Multifamily)       | IE_CD | All | \$109.20 |  | Varies by PA | \$0.01 |  |  |

**Endnotes:**

- 1** : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 2** : NMR Group, Inc. (2018). 2019-2021 Planning Assumptions: Lighting Hours-of-Use and In-Service Rate. [2018 NMR LTGHOU ISR](#)
- 3** : NMR Group, Inc. (2014). Northeast Residential Hours of Use Study. [NMR 2014 Northeast Residential Lighting HOU](#)
- 4** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 5** : NMR Group, Inc. (2020). Residential Lighting Hours-of-Use Quick Hit Study (MA20R21-E). [2019 NMR LightingHOU Update](#)
- 9** : MA PAs (2018). 2019-2021 Lighting Worksheet. [MA PAs Lighting Worksheet PY2019-2021](#)
- 11** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 12** : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 13** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 16** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)

## 2.42. Lighting - Occupancy Sensors

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-L-OS         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Lighting        |

### Measure Description:

The installation of occupancy sensors for lighting fixtures. This measure involves installing an occupancy sensor that controls lighting fixtures and limits their use when the space is unoccupied.

### BCR Measure IDs:

| Measure Name                                | Core Initiative                              | BCR Measure ID |
|---------------------------------------------|----------------------------------------------|----------------|
| Occupancy Sensor, Common Area (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a112        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are based on one of the following algorithms, as appropriate to the situation.

For on/off sensors, savings are as follows:

$$\Delta kWh = (\text{WattsControlled} * \text{Hours} * \text{SVG}) / 1000$$

Where:

Watts controlled = Connected load wattage controlled by Sensor

Hours = Run time of fixture before the installation of sensors

Svg = Percentage by which hours of operation are reduced due to the sensor; site specific

For high/low sensors, savings are as follows:

$$\Delta kWh = ((\text{HighWatts} - \text{LowWatts}) * \text{Hours}) / 1000$$

Where:

HighWatts = Full load of fixture

LowWatts = Wattage of fixture when no occupancy is detected; input by auditor, typically 50% of HighWatts

Hours = Run time of fixture (24 hours, fixtures are always on)

### Baseline Efficiency:

The baseline condition for this measure is a lighting fixture that is not controlled by an occupancy sensor.

**High Efficiency:**

The high efficiency case is a lighting fixture that operates with connected occupancy sensors.

**Measure Life:**

The measure life is 10 years.

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Occupancy Sensor, Common Area | All             | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.13             |

**In-Service Rates:**

In-service rates are set to 100% based on the assumption that all purchased units are installed

**Realization Rates:**

Realization rates are set to 100%.

**Coincidence Factors:**

Coincidence factors come from the Demand Impact Model.<sup>1</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for Residential Coordinated Delivery are from the Guidehouse NTG evaluation.

| Measure Name                                | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Occupancy Sensor, Common Area (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                                | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Occupancy Sensor, Common Area (Multifamily) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |

**Endnotes:**

**1** : Navigant Consulting (2018). Demand Impact Model Update.  
[2018 Navigant Baseline Loadshape Comprehensive Report](#)

## 2.43. Motor - Variable Frequency Drive

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | IE-MAD-VFD        |
| <b>Market</b>       | Income Eligible   |
| <b>Program Type</b> | Retrofit          |
| <b>Category</b>     | Motors and Drives |

### Measure Description:

This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.

### BCR Measure IDs:

| Measure Name                           | Core Initiative                              | BCR Measure ID |
|----------------------------------------|----------------------------------------------|----------------|
| Variable Frequency Drive (Multifamily) | Income Eligible Coordinated Delivery (IE_CD) | EB1a118        |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (HP)(kWh/HP)$$

$$\Delta kW = (HP)(kW/HP_{SP})$$

Where:

HP = Rated horsepower for the impacted motor.

kWh / HP = Annual electric energy reduction based on building and equipment type. See table below.

kW / HP<sub>SP</sub> = Summer demand reduction based on building and equipment type. See table below.

kW / HP<sub>WP</sub> = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.



**Savings Factors for C&I VFDs (kWh/HP<sup>1</sup> and kW/HP<sup>2</sup>)**

| Savings Factor                                       | Building Type | Building Exhaust Fan | Cooling Tower Fan | Chilled Water Pump | Boiler Feed Water Pump | Hot Water Circulating Pump | MAF - Make-up Air Fan | Return Fan | Supply Fan | WS Heat Pump Circulating Loop |
|------------------------------------------------------|---------------|----------------------|-------------------|--------------------|------------------------|----------------------------|-----------------------|------------|------------|-------------------------------|
| Annual Energy Savings Factors (kWh/HP)               | Multi-Family  | 3202                 | 889               | 1374               | 2340                   | 2400                       | 3082                  | 1374       | 1319       | 3713                          |
| Summer Demand Savings Factors (kW/HP <sub>SP</sub> ) | Multi-Family  | 0.109                | -0.023            | 0.174              | 0.457                  | 0.091                      | 0.109                 | 0.287      | 0.274      | 0.218                         |
| Winter Demand Savings Factors (kW/HP <sub>WP</sub> ) | Multi-Family  | 0.109                | -0.006            | 0.184              | 0.355                  | 0.21                       | 0.109                 | 0.26       | 0.252      | 0.282                         |

**Baseline Efficiency:**

The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheats.

**High Efficiency:**

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

**Measure Life:**

The measure life is 13 years.<sup>3</sup>

| Measure Name                           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Variable Frequency Drive (Multifamily) | IE_CD           | All | 13  | n/a | n/a | 13  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                           | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Variable Frequency Drive (Multifamily) | IE_CD           | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 1.00             | 1.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are assumed to be 100%.

**Coincidence Factors:**

Coincidence factors are set to 100% since kW savings are calculated.

**Impact Factors for Calculating Net Savings:**

| Measure Name                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Variable Frequency Drive (Multifamily) | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Variable Frequency Drive (Multifamily) | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |

**Endnotes:**

**1** : Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.

[Chan 2010 Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR](#)

**2** : For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW/HP estimates derived from Cadmus (2012). Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type kW/HP savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR. Prepared for NSTAR.

**3** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

## 2.44. Plug Load - Advanced Power Strip

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-PL-APS       |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Plug Load       |

### Measure Description:

Advanced power strips can automatically eliminate standby power loads of electronic peripheral devices that are not needed (DVD player, computer printer, scanner, etc.) either automatically or when an electronic control device (typically a television or personal computer) is in standby or off mode.

### BCR Measure IDs:

| Measure Name | Core Initiative                              | BCR Measure ID |
|--------------|----------------------------------------------|----------------|
| Smart Strip  | Income Eligible Coordinated Delivery (IE_CD) | EB1a120        |

### Algorithms for Calculating Primary Energy Impact:

Unit kWh savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

### Savings for Smart Strips

| Measure Name | Core Initiative | kWh | kW    |
|--------------|-----------------|-----|-------|
| Smart Strip  | All             | 105 | 0.010 |

### Baseline Efficiency:

The baseline efficiency case is the customers' devices as they are currently operating.

### High Efficiency:

The high efficiency case is the installation of an Advanced Power Strip.

### Measure Life:

The measure life is assumed to be 5 years.

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|
| Smart Strip  | IE_CD           | All | 0.73 | 0.92            | 0.92             | 0.92             | 1.00             | 1.00             |

**In-Service Rates**

In-Service Rates are blended and based on evaluation results.<sup>3 4</sup>

**Realization Rates**

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.<sup>5</sup>

**Coincidence Factors**

Summer and winter coincidence factors are based on referenced study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name | Core Initiative | PA  | NTG  |
|--------------|-----------------|-----|------|
| Smart Strip  | IE_CD           | All | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 
- 1** : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. [2019 NMR APSMeteringReport Revised](#)
  - 2** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
  - 3** : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. [2019 NMR APSMeteringReport Revised](#)
  - 4** : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. [2018 NMR APS Metering Report](#)
  - 5** : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)
  - 6** : Guidehouse (2021). Virtual Home Energy Assessment Study. [2021 Guidehouse VHEA Report FINAL](#)

## 2.45. Refrigeration - Vending Miser

|                     |                 |
|---------------------|-----------------|
| <b>Measure Code</b> | IE-R-VM         |
| <b>Market</b>       | Income Eligible |
| <b>Program Type</b> | Retrofit        |
| <b>Category</b>     | Refrigeration   |

### Measure Description:

Controls can significantly reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.

### BCR Measure IDs:

| Measure Name   | Core Initiative                              | BCR Measure ID |
|----------------|----------------------------------------------|----------------|
| Vending Misers | Income Eligible Coordinated Delivery (IE_CD) | EB1a134        |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (kW_{RATED})(Hours)(SAVE)$$

$$\Delta kW = \Delta kWh / Hours$$

Where:

$kW_{RATED}$  = Rated kW of connected equipment. See for default rated kW by connected equipment type.

Hours = Operating hours of the connected equipment: default of 8,760 hours

SAVE = Percent savings factor for the connected equipment. See table below for values.

### Vending Machine and Cooler Controls Savings Factors<sup>1</sup>

| Equipment Type                         | $kW_{RATED}$ | SAVE (%) | $\Delta kW$ | $\Delta kWh$ |
|----------------------------------------|--------------|----------|-------------|--------------|
| Refrigerated Beverage Vending Machines | 0.40         | 46       | 0.18        | 1612         |

### Baseline Efficiency:

The baseline efficiency case is a standard efficiency refrigerated beverage vending machine without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**High Efficiency:**

The high efficiency case is a standard efficiency refrigerated beverage vending machine with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**Measure Life:**

The measure life is 5 years.<sup>2</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Vending Misers | IE_CD           | All | 5   | n/a | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name   | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Vending Misers | IE_CD           | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates**

All installations have 100% in service rate since all PAs’ programs include verification of equipment installations.

**Realization Rates**

Realization rates are assumed to be 100%.

**Coincidence Factors**

Coincidence factors based on staff estimates- assumed that savings occur during off peak hours.

**Impact Factors for Calculating Net Savings:**

| Measure Name   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------|-----------------|-----|------|-----------------|------------------|------|
| Vending Misers | IE_CD           | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Vending Misers | IE_CD           | All |                    |                      | Varies by PA      | \$0.01              |                     |                       |

**Endnotes:**

- 1 : USA Technologies Energy Management Product Sheets (2006).  
[USA Tech 2006 Energy Management Product Sheets](#)  
 2 : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

## 3. Commercial & Industrial Efficiency Measures

### 3.1. Appliance - Refrigerator/Freezer Recycling

|                     |                                                                          |
|---------------------|--------------------------------------------------------------------------|
| <b>Measure Code</b> | COM-A-RFR                                                                |
| <b>Market</b>       | Commercial                                                               |
| <b>Program Type</b> | Direct Install, Early Replacement, Early Retirement, Recycling, Retrofit |
| <b>Category</b>     | Food Service Equipment                                                   |

#### Measure Description:

Recycling of a qualified refrigerator or freezer.

#### BCR Measure IDs:

| Measure Name           | Core Initiative                           | BCR Measure ID |
|------------------------|-------------------------------------------|----------------|
| Freezer Recycling      | C&I Existing Building Retrofit (CI_RETRO) | EC2a116        |
| Refrigerator Recycling | C&I Existing Building Retrofit (CI_RETRO) | EC2a117        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed and reflect corresponding Residential product offering. For full detail, please reference the Residential measure savings assumptions (measure code RES-A-RFR).

| Measure Name                     | kWh   | kW   |
|----------------------------------|-------|------|
| Freezer Recycling (Turnkey)      | 753   | 0.13 |
| Refrigerator Recycling (Turnkey) | 1,005 | 0.17 |

#### Baseline Efficiency:

The baseline efficiency case is an old, inefficient but working refrigerator or freezer.

#### High Efficiency:

The high efficiency case assumes no replacement of equipment.



**Measure Life:**

The measure life for product recycling is assumed to be 4 years.

| Measure Name                             | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Freezer/Refrigerator Recycling (Turnkey) | CI_RETRO        | All | 4   | n/a | n/a | 4   |

**Other Resource Impacts:**

There are no other resource impacts associated with these measures.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Freezer Recycling (Turnkey)      | CI_RETRO        | All | 1.00 | 0.83            | 0.83             | 0.83             | 0.83             | 0.85             | 0.65             |
| Refrigerator Recycling (Turnkey) | CI_RETRO        | All | 1.00 | 0.90            | 0.90             | 0.90             | 0.90             | 0.85             | 0.85             |

**In-Service Rates:**

Measure leveraging default 100% in-service rate.

**Realization Rates:**

Realization rates are set to the residential impact factors for the same measures.

**Coincidence Factors:**

Coincidence factors are set to the residential coincidence factors for the same measures. Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>1</sup>

| Measure                                  | Core Initiative | PA  | FR    | SO <sub>p</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|-------|-----------------|------------------|------|
| Freezer/Refrigerator Recycling (Turnkey) | CI_RETRO        | All | 0.135 | 0.053           | 0.018            | 0.94 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

1 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018\_NMR\_CI FR-SO Report

### 3.2. Appliance - Room Air Purifier

|                     |              |
|---------------------|--------------|
| <b>Measure Code</b> | COM-PL-RAP   |
| <b>Market</b>       | Commercial   |
| <b>Program Type</b> | Time of Sale |
| <b>Category</b>     | Plug Load    |

#### Measure Description:

Rebates provided for the purchase of an ENERGY STAR® qualified room air cleaner. ENERGY STAR® air cleaners are 40% more energy-efficient than standard models.

#### BCR Measure IDs:

| Measure Name      | Core Initiative                            | BCR Measure ID |
|-------------------|--------------------------------------------|----------------|
| Room Air Purifier | C&I New & Replacement Equipment (CI_EQUIP) | EC2b108        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed per Energy Star appliance calculator.

| Measure Name      | Building Type  | kWh | kW   |
|-------------------|----------------|-----|------|
| Room Air Purifier | K-12           | 214 | 0.08 |
| Room Air Purifier | Office (Small) | 316 | 0.08 |
| Room Air Purifier | Retail (Small) | 373 | 0.08 |

#### Baseline Efficiency:

The baseline efficiency case is a unit with 2.0 CADR/Watt<sub>dust</sub>.

#### High Efficiency:

The current EnergyStar specification requires a minimum of 2.0 CADR/Watt<sub>dust</sub>. However, the ENERGY STAR average CADR/Watt (Dust) of models available in their US market database (approximately 170 models) is approximately 3.5 CADR/Watt<sub>dust</sub>. Therefore it is assumed that the high efficiency unit has a 3.0 CADR/Watt<sub>dust</sub>.

**Measure Life:**

The measure life is 3 years.<sup>2</sup>

| Measure Name      | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------|-----------------|-----|-----|-----|-----|-----|
| Room Air Purifier | CI_EQUIP        | All | 3   | n/a | n/a | 3   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Room Air Purifier | CI_EQUIP        | All | 0.97 | 1.00            | n/a              | 1.00             | 1.00             | 1.00             | 1.00             |

**In-Service Rates:**

In-service rates is based on evaluation results.<sup>3</sup>

**Realization Rates:**

Realization rates are set to 100% since unit savings are deemed.

**Coincidence Factors:**

Summer and winter coincidence factors are calculated assuming that the unit runs continuously, 8760 hours/year.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>5</sup>

| Measure Name      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Purifier | CI_EQUIP        | All | 0.25 | 0.00            | 0.09             | 0.84 |

**Non-Energy Impacts:**

Impact factors are deemed based on study results.<sup>6</sup>

| Measure Name      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Room Air Purifier | CI_EQUIP        | All |                    |                      | 0.14              |                     |                     |                       |

**Endnotes:**

**2** : Per agreement of MA Statewide Ventilation Subcommittee (2021). Measure assumptions were agreed upon by EEAC and PA stakeholders in support of ventilation measures to aid in alleviating COVID risks.

**3** : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. [NMR 2018 Products ISR Study](#)

**5** : NMR Group, Inc. (2021). C&I Custom & Prescriptive Omnibus NTG Study. [2021 NMR C&I Omnibus NTG](#)

**6** : MA20X10-B-CIOMNEI

### 3.3. Behavior - Building Operator Certification

|                     |                |
|---------------------|----------------|
| <b>Measure Code</b> | COM-BS-BOC     |
| <b>Market</b>       | Commercial     |
| <b>Program Type</b> | Retrofit       |
| <b>Category</b>     | Building Shell |

#### Measure Description:

Building Operator Certification (BOC) is a nationally recognized training program designed to educate facilities personnel in the energy and resource efficient operation and maintenance of building systems. Savings include only operations, maintenance and controls savings.

#### BCR Measure IDs:

| Measure Name                                 | Core Initiative                           | BCR Measure ID |
|----------------------------------------------|-------------------------------------------|----------------|
| Other - Building Operator Certification      | C&I Existing Building Retrofit (CI_RETRO) | EC2a028        |
| Other - Building Operator Certification Plus | C&I Existing Building Retrofit (CI_RETRO) | EC2a125        |
| Building Operator Certification, Gas         | C&I Existing Building Retrofit (CI_RETRO) | GC2a001        |
| Building Operator Certification Plus, Gas    | C&I Existing Building Retrofit (CI_RETRO) | GC2a002        |

#### Algorithms for Calculating Primary Energy Impact:

Savings are deemed based on study results.<sup>1</sup>

| Measure Name                                            | kWh / SF / Student | MMBtu / SF / Student |
|---------------------------------------------------------|--------------------|----------------------|
| Building Operator Certification                         | 0.178              | 0.0007               |
| Building Operator Certification Plus (capital upgrades) | 0.364              | 0.0011               |

#### Baseline Efficiency:

No BOC training.

#### High Efficiency:

Completion and certification in a BOC level I or level II training course.

**Measure Life:**

Measure life of 5 years.<sup>2</sup>

| Measure Name                    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------|-----------------|-----|-----|-----|-----|-----|
| Building Operator Certification | CI_RETRO        | All | 5   | n/a | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Building Operator Certification | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 1.00             | 1.00             |

**In-Service Rates:**

All installations have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% since savings are based off of evaluation results.

**Coincidence Factors:**

Coincidence factors are based on Massachusetts Common Assumptions.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide net-to-gross results.<sup>3</sup>

| Measure Name                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Building Operator Certification, Electric | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |
| Building Operator Certification, Gas      | CI_RETRO        | All | 0.22 | 0.03            | 0.00             | 0.80 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

**1** : Navigant Consulting (2015). Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification. [Navigant 2015 BOC Review](#)

**2** : Navigant Consulting (2015). Comprehensive Review of Non-Residential Training and Education Programs, with a Focus on Building Operator Certification. [Navigant 2015 BOC Review](#)

### 3.4. Building Shell - Air Sealing - C&I Multi-Family

|                     |                |
|---------------------|----------------|
| <b>Measure Code</b> | COM-BS-ASREU   |
| <b>Market</b>       | Commercial     |
| <b>Program Type</b> | Retrofit       |
| <b>Category</b>     | Building Shell |

#### Measure Description:

Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                           | BCR Measure ID |
|---------------------------------------------|-------------------------------------------|----------------|
| Air Sealing, Electric (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a059        |
| Air Sealing, Oil (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a060        |
| Air Sealing, Other (Residential End Use)    | C&I Existing Building Retrofit (CI_RETRO) | EC2a111        |
| Air Sealing, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a055        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the following algorithms and assumptions:

$$\begin{aligned} \text{kWh} &= (\text{Vol} \times \text{ACH} \times 0.018 \times \text{HDD} \times 24/\eta_{\text{heating}}) / 3,413 \\ \text{MMBtu} &= (\text{Vol} \times \text{ACH} \times 0.018 \times \text{HDD} \times 24/\eta_{\text{heating}}) / 1,000,000 \\ \text{kW} &= \text{kWh} \times \text{kW/kWh} \end{aligned}$$

Where:

Vol = [ft<sup>3</sup>] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)

ΔACH = [°F-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)

HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below. η<sub>heating</sub> = [AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)

24 = Conversion factor: 24 hours per day

0.018 = [Btu/ft<sup>3</sup>- °F] Air heat capacity: The specific heat of air (0.24 Btu/°F.lb) times the density of air (0.075 lb/ft<sup>3</sup>)

1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu

3413 = Conversion factor: 3413 Btu/kWh

kW/kWh = Average kW reduction per kWh reduction: 0.00073 kW/kWh<sup>1</sup>

### Baseline Efficiency:

The baseline efficiency case is the existing building before the air sealing measure is implemented. The baseline building is characterized by the existing air changes per hour (ACHPRE) for multi-family facilities, which is measured prior to the implementation of the air sealing measure. This will typically be a default value of a baseline/pre-retrofit ACH =0.5.

### High Efficiency:

The high efficiency case is the existing building after the air sealing measure is implemented. The high efficiency building is characterized by the new air changes per hour (ACHPOST) for multi-family facilities, which is measured after the air sealing measure is implemented. This will typically be a default value of a baseline/pre-retrofit ACH =0.4.

### Measure Life:

The measure life is 15 years.<sup>2</sup>

| Measure Name                      | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------|-----------------|-----|-----|-----|-----|-----|
| Air Sealing (Residential End Use) | CI_RETRO        | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Air Sealing, Electric (Residential End Use) | CI_RETRO        | All | 1.00 | 0.86            | n/a              | 0.86             | 0.86             | 0.00             | 0.43             |
| Air Sealing, Oil (Residential End Use)      | CI_RETRO        | All | 1.00 | 0.86            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Other (Residential End Use)    | CI_RETRO        | All | 1.00 | 0.86            | 0.86             | n/a              | n/a              | n/a              | n/a              |
| Air Sealing, Gas (Residential End Use)      | CI_RETRO        | All | 1.00 | 0.86            | 0.86             | n/a              | n/a              | n/a              | n/a              |



**In-Service Rates:**

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

**Realization Rates:**

Realization rates are based on evaluation results.<sup>3</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>5</sup>

| Measure Name                      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Air Sealing (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>6</sup>

| Measure Name                      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Air Sealing (Residential End Use) | CI_RETRO        | All | 19.35              |                      |                   |                     |                     |                       |

**Endnotes:**

- 
- 1** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
  - 2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for the New England State Program Working Group.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
  - 3** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.  
[2018 Navigant Multifamily Program Impact Evaluation](#)
  - 4** : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
  - 6** : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.  
[Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

### 3.5. Building Shell - Insulation - C&I Metered Multi-Family

|                     |                |
|---------------------|----------------|
| <b>Measure Code</b> | COM-BS-IREU    |
| <b>Market</b>       | Commercial     |
| <b>Program Type</b> | Retrofit       |
| <b>Category</b>     | Building Shell |

#### Measure Description:

Insulation upgrades are applied in existing multifamily facilities.

#### BCR Measure IDs:

| Measure Name                                                             | Core Initiative                           | BCR Measure ID |
|--------------------------------------------------------------------------|-------------------------------------------|----------------|
| Insulation, Electric (Residential End Use)                               | C&I Existing Building Retrofit (CI_RETRO) | EC2a061        |
| Insulation, Central AC in Electrically-Heated Unit (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a062        |
| Insulation, Oil (Residential End Use)                                    | C&I Existing Building Retrofit (CI_RETRO) | EC2a063        |
| Insulation, Other (Residential End Use)                                  | C&I Existing Building Retrofit (CI_RETRO) | EC2a112        |
| Insulation, Gas (Residential End Use)                                    | C&I Existing Building Retrofit (CI_RETRO) | GC2a056        |
| Insulation, Gas, with Central AC (Residential End Use)                   | C&I Existing Building Retrofit (CI_RETRO) | GC2a057        |

#### Algorithms for Calculating Primary Energy Impact:

$$\text{MMBtu}_{\text{annual}} = ((1/R_{\text{exist}} - 1/R_{\text{new}}) * \text{HDD} * 24 * \text{Area}) / (1000000 * \eta_{\text{heat}})$$

$$\text{kWh}_{\text{annual}} = \text{MMBtu}_{\text{annual}} * 293.1$$

$$\text{kW} = \text{kWh}_{\text{annual}} * \text{kW/kWh}_{\text{heating}}$$

Where:

$R_{\text{exist}}$  = Existing effective R-value (R-ExistingInsulation + R-Assembly), ft<sup>2</sup>-°F/Btuh

$R_{\text{new}}$  = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft<sup>2</sup>-°F/Btuh

Area = Square footage of insulated area

$\eta_{\text{heat}}$  = Efficiency of the heating system (AFUE or COP)

293.1 = Conversion constant (1MMBtu = 293.1 kWh)

24 = Conversion for hours per day

HDD = Heating Degree Days; dependent on location, see table below  
 1,000,000 = Conversion from Btu to MMBtu  
 kW/kWh heating = Average annual kW reduction per kWh reduction.<sup>1</sup>

| Measure                                            | kW/kWh Factor |
|----------------------------------------------------|---------------|
| Insulation (Electric)                              | 0.00073       |
| Insulation (Gas, Oil, Other FF)                    | 0.00076       |
| Insulation, Central AC in Electrically-Heated Unit | 0.00059       |

### Baseline Efficiency:

The baseline efficiency case is characterized by the total R-value of the existing attic, basement or sidewall (Rexist). This is calculated as the R-value of the existing insulation, estimated by the program contractor, plus the R-value of the ceiling, floor, or wall (for all projects: RCEILING = 3.36; RFLOOR = 6.16; RWALL = 6.65).<sup>2</sup>

### High Efficiency:

The high efficiency case is characterized by the total R-value of the attic after the installation of additional attic, basement or sidewall insulation. This is calculated as the sum of the existing R-value (Rexist) plus the R-value of the added insulation.

### Measure Life:

The measure life is 25 years.<sup>3</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Insulation   | CI_RETRO        | All | 25  | n/a | n/a | 25  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                                             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Insulation, Electric (Residential End Use)                               | CI_RETRO        | All | 1.00 | 0.86            | n/a              | 0.86             | 0.86             | 0.00             | 0.43             |
| Insulation, Central AC in Electrically-Heated Unit (Residential End Use) | CI_RETRO        | All | 1.00 | 0.86            | n/a              | 0.86             | 0.86             | 0.50             | 0.04             |
| Insulation, Gas (Residential End Use)                                    | CI_RETRO        | All | 1.00 | n/a             | 0.86             | n/a              | n/a              | n/a              | n/a              |

|                                                        |          |     |      |      |      |      |      |      |      |
|--------------------------------------------------------|----------|-----|------|------|------|------|------|------|------|
| Insulation, Gas, with Central AC (Residential End Use) | CI_RETRO | All | 1.00 | 1.00 | 0.86 | 1.00 | 1.00 | 0.50 | 0.04 |
| Insulation, Oil (Residential End Use)                  | CI_RETRO | All | 1.00 | n/a  | 0.86 | n/a  | n/a  | n/a  | n/a  |
| Insulation, Other (Residential End Use)                | CI_RETRO | All | 1.00 | n/a  | 0.86 | n/a  | n/a  | n/a  | n/a  |

**In-Service Rates:**

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

**Realization Rates:**

Realization rates are based on evaluation results.<sup>4</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors based on evaluation results.<sup>6</sup>

| Measure Name                     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Insulation (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Insulation (Residential End Use) | CI_RETRO        | All | \$47.31            |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 2 : Assumptions from National Grid program vendor.
- 3 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 4 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.

[2018 Navigant Multifamily Program Impact Evaluation](#)

**5** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**6** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.

[2021 Guidehouse MA Res NTG Final Report](#)

### 3.6. Compressed Air - Air Nozzle

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-CA-AN        |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | New Construction |
| <b>Category</b>     | Compressed Air   |

#### Measure Description:

Covers the installation of engineered air nozzles which provide effective air nozzle action while reducing compressed air system air flow.

#### BCR Measure IDs:

| Measure Name                | Core Initiative                                  | BCR Measure ID |
|-----------------------------|--------------------------------------------------|----------------|
| Compressed Air – Air Nozzle | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a007        |
| Compressed Air – Air Nozzle | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b007        |

#### Algorithms for Calculating Primary Energy Impact:

Savings are calculated in a spreadsheet tool per the following:

$$\text{Delta\_kW} = \text{Delta\_kWh} / \text{hr}$$

$$\text{Delta\_kWh} = (\text{FLOW\_base} - \text{FLOW\_eng}) \times \text{kW\_SCFM} \times \text{USE} \times \text{hr}$$

Where:

FLOW\_base = open nozzle flow at 100 psi (site specific)

FLOW\_eng = engineered nozzle flow at 100 psi (site specific)

hr = annual operating hours

kW\_SCFM = 0.29 (site specific if available)

USE = 0.05 (site specific if available)

#### Baseline Efficiency:

The baseline is a standard nozzle on a compressed air system.

#### High Efficiency:

The high efficient case is the same air compressor with an engineered nozzle.

**Measure Life:**

The measure life is 13 years.<sup>1</sup>

| Measure Name | PA  | Core Initiative    | EUL | OYF | RUL | AML |
|--------------|-----|--------------------|-----|-----|-----|-----|
| Air Nozzle   | All | CI_NB&MR, CI_EQUIP | 13  | n/a | n/a | 13  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative    | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|--------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Air Nozzle   | CI_NB&MR, CI_EQUIP | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.27             | 0.26             |

**In-Service Rates:**

All installations have 100% in-service rates since PA programs include verification of equipment installations.

**Realization Rates:**

RRs set to 1.0 since unevaluated.

**Coincidence Factors:**

CFs from 2016 DMI impact evaluation of CAIR.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross values based on study results.<sup>2</sup>

| Measure Name | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------|-----------------|-----|-------|-----------------|------------------|-------|
| Air Nozzle   | CI_NB&MR        | All | 0.583 | 0.225           | 0.00             | 0.642 |
| Air Nozzle   | CI_EQUIP        | All | n/a   | n/a             | n/a              | 0.658 |

**Non-Energy Impacts:**

NEIs for this measure are from the 2021 C&I O&M and non-O&M NEI study. Health & safety NEI impacts are negotiated based on discussions with EEAC consultants.

| Measure Name                | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Compressed Air - Air Nozzle | CI_NB&MR        | All | 0                  | 0                    | \$0.042           | 0                   | 0                   | 0                     |
| Compressed Air - Air Nozzle | CI_EQUIP        | All | 0                  | 0                    | \$0.042           | 0                   | 0                   | 0                     |

**Endnotes:**

- 1 : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)  
 2 : NMR Group, Inc. (2021). C&I Omnibus NTG Study [2021 NMR C&I Omnibus NTG](#)



### 3.7. Compressed Air - High Efficiency Air Compressor

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-CA-HEAC      |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | New Construction |
| <b>Category</b>     | Compressed Air   |

#### Measure Description:

Covers the installation of oil flooded, rotary screw compressors with Variable Speed Drive or Variable Displacement capacity control with properly sized air receiver. Efficient air compressors use various control schemes to improve compression efficiencies at partial loads.

#### BCR Measure IDs:

| Measure Name                                     | Core Initiative                            | BCR Measure ID |
|--------------------------------------------------|--------------------------------------------|----------------|
| Compressed Air - High Efficiency Air Compressors | C&I New & Replacement Equipment (CL_EQUIP) | EC2b003        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (HP_{COMPRESSOR}) \times (Save) \times (Hours)$$

$$\Delta kW = (HP_{COMPRESSOR}) \times (Save)$$

Where:

$HP_{COMPRESSOR}$  = Nominal rated horsepower of high efficiency air compressor.

Save = Air compressor kW reduction per HP: 0.189. <sup>1</sup>

Hours = Annual operating hours of the air compressor.

#### Baseline Efficiency:

The baseline efficiency case is a typical load/unload compressor.

#### High Efficiency:

The high efficient case is an oil-flooded, rotary screw compressor with Variable Speed Drive or Variable Displacement capacity control with a properly sized air receiver. Air receivers are designed to provide a supply buffer to meet short-term demand spikes which can exceed the compressor capacity. Installing a larger receiver tank to meet occasional peak demands can allow for the use of a smaller compressor.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name                                     | Core Initiative    | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------------|--------------------|-----|-----|-----|-----|-----|
| Compressed Air - High Efficiency Air Compressors | CI_NB&MR, CI_EQUIP | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                     | Core Initiative    | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------------|--------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Compressed Air - High Efficiency Air Compressors | CI_NB&MR, CI_EQUIP | All | 1.00 | 1.39            | 1.39             | 1.00             | 1.00             | 0.27             | 0.26             |

**In-Service Rates:**

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

**Realization Rates:**

RR from the prospective results of the 2015 study of prescriptive compressed air. The RR adjusts for differences in operating hours between PA tracking assumptions and on site findings. The RR must be coupled with the updated kW/HP results from the same study, referenced in the Algorithm section above.<sup>3</sup>

**Coincidence Factors:**

CFs from the prospective results of the 2015 study of prescriptive compressed air.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross values based on the 2021 C&I Omnibus NTG Study<sup>5</sup>

| Measure Name                                    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------------------------|-----------------|-----|------|-----------------|------------------|-------|
| Compressed Air - High Efficiency Air Compressor | CI_NB&MR        | All | 0.33 | 0.03            | 0.03             | 0.837 |
| Compressed Air - High Efficiency Air Compressor | CI_EQUIP        | All | 0.23 | 0.09            | 0.00             | 0.878 |

**Non-Energy Impacts:**

NEIs for this measure are from the 2021 C&I O&M and non-O&M NEI study. Health & safety NEI impacts are negotiated based on discussions with EEAC consultants.

| Measure Name                                    | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Compressed Air - High-Efficiency Air Compressor | CI_NB&MR        | All | \$0.00             | \$0.00               | \$0.002           | \$0.00              | \$0.00              | \$0.00                |
| Compressed Air - High-Efficiency Air Compressor | CI_EQUIP        | All | \$0.00             | \$0.00               | \$0.002           | \$0.00              | \$0.00              | \$0.00                |

**Endnotes:**

**1** : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. Result for VSD 25-75 HP used since “All” result includes savings from load/unload compressors, which are now baseline.

[DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)

**2** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

**3** : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations.

[DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)

**4** : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations.

[DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)

**5** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.8. Compressed Air - Low Pressure Drop Filter

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-CA-LPDF      |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | New Construction |
| <b>Category</b>     | Compressed Air   |

#### Measure Description:

Filters remove solids and aerosols from compressed air systems. Low pressure drop filters have longer lives and lower pressure drops than traditional coalescing filters, resulting in higher efficiencies.

#### BCR Measure IDs:

| Measure Name                               | Core Initiative                                  | BCR Measure ID |
|--------------------------------------------|--------------------------------------------------|----------------|
| Compressed Air – Low Pressure Drop Filters | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a005        |
| Compressed Air – Low Pressure Drop Filters | C&I Existing Building Retrofit (CI_RETRO)        | EC2a004        |
| Compressed Air – Low Pressure Drop Filters | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b005        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = [(HP_{comp}) \times (0.7457) / \text{eff}] \times [((\text{Existing P}) - (\text{Adjusted P})) / (2 \times 100)] \times (\text{Hours})$$

$$\Delta kW = [(HP_{comp}) \times (0.7457) / \text{eff}] \times [((\text{Existing P}) - (\text{Adjusted P})) / (2 \times 100)]$$

Where:

$\Delta kWh$  = Energy savings

$\Delta kW$  = Demand savings

HPCOMP = Average compressor load. Site specific.

0.7457 = Conversion from HP to kW

eff = Full Load NEMA Premium Motor Efficiency - see below

2 x 100 = % Savings calculated with the assumption that for every 2 psi increase in discharge pressure, energy consumption will increase by approximately 1%

Hours = Annual operating hours of the lower pressure drop filter. Site specific.

#### NEMA Premium Motor Full Load Efficiency:

| HP | Efficiency |
|----|------------|
| 15 | 92.4%      |
| 20 | 93.0%      |

|    |       |
|----|-------|
| 25 | 93.6% |
| 30 | 93.6% |
| 40 | 94.1% |
| 50 | 94.5% |
| 60 | 95.0% |
| 75 | 95.4% |

Savings algorithm source: PA calculation tool, "Prescriptive\_CAIR\_ZLD\_LPDPF\_Tool.xlsx" (2016)

**Baseline Efficiency:**

The baseline efficiency case is a standard coalescing filter with initial drop of between 1 and 2 pounds per sq inch (psi) with an end of life drop of 10 psi.

**High Efficiency:**

The high efficiency case is a low pressure drop filter with initial drop not exceeding 1 psi over life and 3 psi at element change. Filters must be deep-bed, “mist eliminator” style and installed on a single operating compressor rated 15 - 75 HP.

**Measure Life:**

The measure life is 5 years. This measure was determined to be an add-on single baseline measure for retrofit installations.<sup>1</sup>

| Measure Name                               | Core Initiative    | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------|--------------------|-----|-----|-----|-----|-----|
| Compressed Air - Low Pressure Drop Filters | CI_NB&MR, CI_EQUIP | All | 5   | n/a | n/a | 5   |
| Compressed Air - Low Pressure Drop Filters | CI_RETRO           | All | 5   | 1   | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                               | Core Initiative              | PA                    | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------|------------------------------|-----------------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Compressed Air - Low Pressure Drop Filters | CI_NB&MR, CI_EQUIP, CI_RETRO | National Grid, Unitil | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.27             | 0.26             |
| Compressed Air - Low Pressure Drop Filters | CI_NB&MR, CI_EQUIP, CI_RETRO | Eversource, CLC       | 1.00 | 1.25            | n/a              | 0.95             | 0.80             | 0.27             | 0.26             |

### In-Service Rates:

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

### Realization Rates:

- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.<sup>2</sup>
- Eversource, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations<sup>3</sup>

### Coincidence Factors:

- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations<sup>4</sup>
- Eversource, CLC: on-peak CFs based on standard assumptions.

### Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross values based on study results.<sup>5</sup>

| Measure Name                               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Compressed Air - Low Pressure Drop Filters | CI_NB&MR        | All | 0.58 | 0.22            | 0.00             | 0.64 |
| Compressed Air - Low Pressure Drop Filters | CI_EQUIP        | All | 0.23 | 0.09            | 0.00             | 0.86 |
| Compressed Air - Low Pressure Drop Filters | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |

### Non-Energy Impacts:

NEIs for this measure are from the 2021 C&I O&M and non-O&M NEI study. Health & safety NEI impacts are negotiated based on discussions with EEAC consultants.

| Measure Name                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Compressed Air - Low-Pressure Drop Filter | CI_NB&MR        | All | \$0.00             | \$0.00               | \$ 0.042          | \$0.00              | \$0.00              | \$0.00                |
| Compressed Air - Low-Pressure Drop Filter | CI_RETRO        | All | \$0.00             | \$0.00               | \$ 0.005          | \$0.00              | \$0.00              | \$0.00                |
| Compressed Air - Low-Pressure Drop Filter | CI_EQUIP        | All | \$0.00             | \$0.00               | \$ 0.042          | \$0.00              | \$0.00              | \$0.00                |

### Endnotes:

- 1** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)
- 2** : DMI (2006). Impact Evaluation of 2004 Compressed Air Prescriptive Rebates. Results analyzed in RLW Analytics (2006). Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in Energy Initiative and Design 2000 Programs. [DMI 2006 Impact Evaluation of 2004 Compressed Air Prescriptive Rebates](#)
- 3** : RLW Analytics (2008). Business & Construction Solutions (BS/BC) Programs Measurement & Verification - 2006 Final Report. [RLW 2008 Business and Construction Solutions Programs Measurement and Verification 2006 Final Report](#)
- 4** : DMI (2006). Impact Evaluation of 2004 Compressed Air Prescriptive Rebates. Results analyzed in RLW Analytics (2006). Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in Energy Initiative and Design 2000 Programs. [DMI 2006 Impact Evaluation of 2004 Compressed Air Prescriptive Rebates](#)
- 5** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.9. Compressed Air - Refrigerated Air Dryer

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-CA-RAD       |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | New Construction |
| <b>Category</b>     | Compressed Air   |

#### Measure Description:

The installation of cycling or variable frequency drive (VFD)-equipped refrigerated compressed air dryers. Refrigerated air dryers remove the moisture from a compressed air system to enhance overall system performance. An efficient refrigerated dryer cycles on and off or uses a variable speed drive as required by the demand for compressed air instead of running continuously. Only properly sized refrigerated air dryers used in a single-compressor system are eligible.

#### BCR Measure IDs:

| Measure Name                             | Core Initiative                                  | BCR Measure ID |
|------------------------------------------|--------------------------------------------------|----------------|
| Compressed Air - Refrigerated Air Dryers | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a004        |
| Compressed Air - Refrigerated Air Dryers | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b004        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (CFM_{DRYER}) \times (Save) \times (HRS)$$

$$\Delta kW = (CFM_{DRYER}) \times (Save)$$

Where:

CFM<sub>DRYER</sub> = Full flow rated capacity of the refrigerated air dryer in cubic feet per minute (CFM).

Obtain from equipment's Compressed Air Gas Institute Datasheet.

Save = Refrigerated air dryer kW reduction per dryer full flow rated CFM: 0.00554.<sup>1</sup>

Hours = Annual operating hours of the refrigerated air dryer.

#### Baseline Efficiency:

The baseline efficiency case is a non-cycling refrigerated air dryer.

#### High Efficiency:

The high efficiency case is a cycling refrigerated dryer or a refrigerated dryer equipped with a VFD.



**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name                             | Core Initiative    | PA  | EUL | OYF | RUL | AML |
|------------------------------------------|--------------------|-----|-----|-----|-----|-----|
| Compressed Air - Refrigerated Air Dryers | CI_NB&MR, CI_EQUIP | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                             | Core Initiative    | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------|--------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Compressed Air - Refrigerated Air Dryers | CI_NB&MR, CI_EQUIP | All | 1.00 | 1.56            | n/a              | 1.00             | 1.00             | 0.22             | 0.22             |

**In-Service Rates:**

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

**Realization Rates:**

RR from the prospective results of the 2015 study of prescriptive compressed air. The RR adjusts for differences in operating hours between PA tracking assumptions and on site findings. The RR must be coupled with the updated kW/CFM results from the same study.<sup>3</sup>

**Coincidence Factors:**

CFs from the prospective results of the 2015 study of prescriptive compressed air.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross values based on study results.<sup>5</sup>

| Measure Name                             | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Compressed Air - Refrigerated Air Dryers | CI_NB&MR        | All | 0.58 | 0.22            | 0.00             | 0.64 |
| Compressed Air - Refrigerated Air Dryers | CI_EQUIP        | All | 0.23 | 0.09            | 0.00             | 0.86 |

### Non-Energy Impacts:

NEIs for this measure are from the 2021 C&I O&M and non-O&M NEI study. Health & safety NEI impacts are negotiated based on discussions with EEAC consultants.

| Measure Name                            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Compressed Air - Refrigerated Air Dryer | CI_NB&MR        | All | \$0.00             | \$0.00               | \$ 0.002          | \$0.00              | \$0.00              | \$0.00                |
| Compressed Air - Refrigerated Air Dryer | CI_EQUIP        | All | \$0.00             | \$0.00               | \$ 0.002          | \$0.00              | \$0.00              | \$0.00                |

### Endnotes:

- 1 : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. [DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)
- 2 : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)
- 3 : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. [DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)
- 4 : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. [DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)
- 5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.10. Compressed Air - Zero Loss Condensate Drain

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-CA-ZLCD      |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | New Construction |
| <b>Category</b>     | Compressed Air   |

#### Measure Description:

Drains remove water from a compressed air system. Zero loss condensate drains remove water from a compressed air system without venting any air, resulting in less air demand and consequently greater efficiency.

#### BCR Measure IDs:

| Measure Name                                 | Core Initiative                                  | BCR Measure ID |
|----------------------------------------------|--------------------------------------------------|----------------|
| Compressed Air – Zero Loss Condensate Drains | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a006        |
| Compressed Air – Zero Loss Condensate Drains | C&I Existing Building Retrofit (CI_RETRO)        | EC2a005        |
| Compressed Air – Zero Loss Condensate Drains | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b006        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (\text{Quantity}) \times (\text{CFM}_{\text{pipe}}) \times (\text{CFM}_{\text{save}}) \times (\text{Save}) \times (\text{Hours})$$

$$\Delta kW = (\text{Quantity}) \times (\text{CFM}_{\text{pipe}}) \times (\text{CFM}_{\text{save}}) \times (\text{Save})$$

Where:

$\Delta kWh$  = Energy savings

$\Delta kW$  = Demand savings

CFM<sub>pipe</sub> = CFM capacity of piping. Site specific.

CFM<sub>saved</sub> = Average CFM saved per CFM of piping capacity: 0.049

Save = Average savings per CFM: 0.210 kW/CFM<sup>1</sup>

Hours = Annual operating hours of the zero loss condensate drain

#### Baseline Efficiency:

The baseline efficiency case is installation of a standard condensate drain on a compressor system.

#### High Efficiency:

The high efficiency case is installation of a zero loss condensate drain on a single operating compressor rated  $\leq 75$  HP.

**Measure Life:**

This measure has been determined to be an add on single baseline measure for retrofit installations.<sup>2</sup>

| Measure Name                                 | Core Initiative       | PA  | EUL | OYF | RUL | AML |
|----------------------------------------------|-----------------------|-----|-----|-----|-----|-----|
| Compressed Air - Zero Loss Condensate Drains | CI_NB&MR,<br>CI_EQUIP | All | 15  | n/a | n/a | 15  |
| Compressed Air - Zero Loss Condensate Drains | CI_RETRO              | All | 15  | 1   | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                 | Core Initiative                    | PA                    | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------|------------------------------------|-----------------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Compressed Air - Zero Loss Condensate Drains | CI_NB&MR,<br>CI_EQUIP,<br>CI_RETRO | National Grid, Unutil | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.80             | 0.54             |
| Compressed Air - Zero Loss Condensate Drains | CI_NB&MR,<br>CI_EQUIP,<br>CI_RETRO | Eversource, CLC       | 1.00 | 1.25            | 1.25             | 0.95             | 0.80             | 0.88             | 0.69             |

**In-Service Rates:**

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

**Realization Rates<sup>3</sup> :**

- National Grid, Unutil: RRs based on impact evaluation of PY 2004 compressed air installations.<sup>4</sup>
- Eversource, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations.<sup>5</sup>

**Coincidence Factors:**

- National Grid, Unutil: CFs based on impact evaluation of PY 2004 compressed air installations.<sup>6</sup>
- Eversource, CLC: on-peak CFs based on standard assumptions.

## Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross values based on study results.<sup>7</sup>

| Measure Name                                | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Compressed Air - Zero Loss Condensate Drain | CI_NB&MR        | All | 0.58 | 0.22            | 0.00             | 0.64 |
| Compressed Air - Zero Loss Condensate Drain | CI_EQUIP        | All | 0.23 | 0.09            | 0.00             | 0.86 |
| Compressed Air - Zero Loss Condensate Drain | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |

## Non-Energy Impacts:

NEIs for this measure are from the 2021 C&I O&M and non-O&M NEI study. Health & safety NEI impacts are negotiated based on discussions with EEAC consultants.

| Measure Name                                | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Compressed Air - Zero-Loss Condensate Drain | CI_NB&MR        | All | \$0.00             | \$0.00               | \$0.042           | \$0.00              | \$0.00              | \$0.00                |
| Compressed Air - Zero-Loss Condensate Drain | CI_RETRO        | All | \$0.00             | \$0.00               | \$0.005           | \$0.00              | \$0.00              | \$0.00                |
| Compressed Air - Zero-Loss Condensate Drain | CI_EQUIP        | All | \$0.00             | \$0.00               | \$0.042           | \$0.00              | \$0.00              | \$0.00                |

## Endnotes:

**1** : Savings algorithm source: PA calculation tool, "Prescriptive\_CAIR\_ZLD\_LPDPF\_Tool.xlsx" (2016)

**2** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet.. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo. [2018 DNVGL ERS Portfolio Model Companion Sheet](#)

**3** : This measure was included in the 2015 DNV GL study of Prescriptive compressed air measures, however, there were not a statistically significant number of sites with this measure selected in the sample, so no impact updates have been made

**4** : DMI (2006). Impact Evaluation of 2004 Compressed Air Prescriptive Rebates. Prepared for National Grid; results analyzed in RLW Analytics (2006). Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs. Prepared for National Grid [DMI 2006 Impact Evaluation of 2004 Compressed Air Prescriptive Rebates](#)

**5** : RLW Analytics (2008). Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report. Prepared for NSTAR Electric and Gas; Table 17. [RLW 2008 Business and Construction Solutions Programs Measurement and Verification 2006 Final Report](#)

**6** : DMI (2006). Impact Evaluation of 2004 Compressed Air Prescriptive Rebates. Prepared for National Grid; results analyzed in RLW Analytics (2006). Sample Design and Impact Evaluation Analysis for

Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs. Prepared for National Grid. [DMI 2006 Impact Evaluation of 2004 Compressed Air Prescriptive Rebates](#)  
7 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.11. Custom - C&I Metered Multi-Family

|                     |              |
|---------------------|--------------|
| <b>Measure Code</b> | COM-CM-CMREU |
| <b>Market</b>       | Commercial   |
| <b>Program Type</b> | Retrofit     |
| <b>Category</b>     | Custom       |

#### Measure Description:

Vendors install a variety of electric and gas measures at multifamily facilities. The measures covered in this entry are associated with commercial gas and electric meters. Measures include lighting, HVAC, and domestic hot water equipment and measures.

#### BCR Measure IDs:

| Measure Name                                      | Core Initiative                           | BCR Measure ID |
|---------------------------------------------------|-------------------------------------------|----------------|
| Custom - HVAC (Residential End Use)               | C&I Existing Building Retrofit (CI_RETRO) | EC2a102        |
| Custom - Water Heating (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a103        |
| Custom - Process (Residential End Use)            | C&I Existing Building Retrofit (CI_RETRO) | EC2a105        |
| Custom - Other (Residential End Use)              | C&I Existing Building Retrofit (CI_RETRO) | EC2a110        |
| Custom - CHP (Residential End Use)                | C&I Existing Building Retrofit (CI_RETRO) | EC2a106        |
| Custom - Lighting Systems (Residential End Use)   | C&I Existing Building Retrofit (CI_RETRO) | EC2a104        |
| Heating, Gas - Custom (Residential End Use)       | C&I Existing Building Retrofit (CI_RETRO) | GC2a050        |
| Process, Gas - Custom (Residential End Use)       | C&I Existing Building Retrofit (CI_RETRO) | GC2a051        |
| Water Heating, Gas - Custom (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | GC2a052        |
| Lighting, Interior - Custom (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | GC2a053        |
| Lighting, Exterior - Custom (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | GC2a054        |
| Demand Circulator (Residential End Use)           | C&I Existing Building Retrofit (CI_RETRO) | GC2a070        |

### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings estimates for custom Residential End Use projects are calculated by approved vendors with project-specific details. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis.

### Baseline Efficiency:

For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

### High Efficiency:

The high efficiency scenario is specific to the facility and may include one or more energy efficiency measures.

### Measure Life:

Measure lives are determined on a case-by-case basis.

### Other Resource Impacts:

Other resource impacts are determined on a case-by-case basis.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                 | Core Initiative | PA         | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------|-----------------|------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Custom - HVAC (Residential End Use)          | CI_RETRO        | All        | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - Water Heating (Residential End Use) | CI_RETRO        | All        | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - Process (Residential End Use)       | CI_RETRO        | All        | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - Other (Residential End Use)         | CI_RETRO        | All        | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.00             | 0.00             |
| Custom - Lighting (Residential End Use)      | CI_RETRO        | CLC        | 1.00 | 0.93            | 0.93             | 0.94             | 0.78             | custom           | custom           |
|                                              | CI_RETRO        | Eversource | 1.00 | 1.01            | 1.01             | 0.94             | 0.79             | custom           | custom           |



|                                           |          |               |      |      |      |      |      |              |              |
|-------------------------------------------|----------|---------------|------|------|------|------|------|--------------|--------------|
|                                           | CI_RETRO | National Grid | 1.00 | 0.96 | 0.96 | 1.02 | 0.93 | custom       | custom       |
|                                           | CI_RETRO | Unitil        | 1.00 | 1.01 | 1.01 | 1.00 | 0.85 | custom       | custom       |
| Custom - CHP<br>(Residential End Use)     | CI_RETRO | CLC           | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | varies by PA | varies by PA |
|                                           | CI_RETRO | Eversource    | 1.00 | 1.10 | 1.22 | 1.44 | 1.01 | varies by PA | varies by PA |
|                                           | CI_RETRO | National Grid | 1.00 | 0.91 | 1.02 | 1.09 | 1.05 | varies by PA | varies by PA |
|                                           | CI_RETRO | Unitil        | 1.00 | 0.90 | 1.12 | 1.26 | 1.58 | varies by PA | varies by PA |
| All Gas -<br>Custom (Residential End Use) | CI_RETRO | All           | 1.00 | n/a  | 0.86 | n/a  | n/a  | n/a          | n/a          |

**In-Service Rates:**

All installations have 100% in-service rates since all PA programs include verification of equipment installations.

**Realization Rates:**

- Lighting: RRs based on evaluation of PY2018-PY2019 projects.<sup>1</sup>
- **CHP - Custom:** RRs based on evaluation of PY 2012 projects.<sup>2</sup> Unitil uses statewide results given their small sample size. Note that RR<sub>NE</sub> applies to project fossil fuel penalty.
- Remaining realization rates are based on multifamily impact evaluation study.<sup>3</sup>

**Coincidence Factors:**

For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide net-to-gross values based on study results.<sup>4</sup>

| Measure Name                                   | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------|-----------------|-----|-------|-----------------|------------------|------|
| Non-Lighting - Custom<br>(Residential End Use) | CI_RETRO        | All | 0.046 | 0.013           | 0.053            | 1.02 |
| Lighting - Custom<br>(Residential End Use)     | CI_RETRO        | All | 0.36  | 0.00            | 0.02             | 0.66 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>5</sup>

| Measure Name                                      | Core Initiative | PA        | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------------|-----------------|-----------|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| HVAC - Custom (Residential End Use)               | CI_RETRO        | Statewide |                    |                      | \$0.051           |                     |                     |                       |
| Water Heating - Custom (Residential End Use)      | CI_RETRO        | Statewide |                    |                      | \$0.065           |                     |                     |                       |
| Process - Custom (Residential End Use)            | CI_RETRO        | Statewide |                    |                      | \$0.098           |                     |                     |                       |
| Other - Custom (Residential End Use)              | CI_RETRO        | Statewide |                    |                      | \$0.098           |                     |                     |                       |
| Custom - Lighting Systems (Residential End Use)   | CI_RETRO        | Statewide |                    |                      | \$0.095           |                     |                     |                       |
| CHP (Residential End Use)                         | CI_RETRO        | Statewide |                    |                      | \$0.098           |                     |                     |                       |
| Heating, Gas - Custom (Residential End Use)       | CI_RETRO        | Statewide |                    |                      |                   |                     | (\$0.037)           |                       |
| Process, Gas - Custom (Residential End Use)       | CI_RETRO        | Statewide |                    |                      |                   |                     | (\$0.045)           |                       |
| Water Heating, Gas - Custom (Residential End Use) | CI_RETRO        | Statewide |                    |                      |                   |                     | \$0.349             |                       |
| Demand Circulator, Gas (Residential End Use)      | CI_RETRO        | Statewide |                    |                      |                   |                     | (\$0.037)           |                       |

### Endnotes:

1: Impact Evaluation of PY2018-2019 Custom Electric Installations, Draft Results Memo. DNV GL (2021) [2021 DNV Custom Electric MA20C04](#)

2: KEMA 2013. Massachusetts Combined Heat and Power Program Impact Evaluation, 2011-2012 [KEMA 2013 MA CI CHP IMPACT EVAL](#)

3: Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation

[2018 Navigant Multifamily Program Impact Evaluation](#)

**4:** NMR Group, Inc. (2021). C&I Prescriptive and Custom NTG Omnibus Study

[2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)

**5:** NMR Group, Inc. (2021). C&I O&M and Non-O&M Non-Energy Impacts Study. [2021 NMR CIOM and NonOM NEI Study](#)

### 3.12. Custom - C&I Turnkey

|                     |              |
|---------------------|--------------|
| <b>Measure Code</b> | COM-CM-CMTRN |
| <b>Market</b>       | Commercial   |
| <b>Program Type</b> | Retrofit     |
| <b>Category</b>     | Custom       |

#### Measure Description:

The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.

#### BCR Measure IDs:

| Measure Name                           | Core Initiative                           | BCR Measure ID |
|----------------------------------------|-------------------------------------------|----------------|
| Custom - Compressed Air (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a043        |
| Custom - Water Heating (Turnkey)       | C&I Existing Building Retrofit (CI_RETRO) | EC2a044        |
| Custom - HVAC (Turnkey)                | C&I Existing Building Retrofit (CI_RETRO) | EC2a046        |
| Custom - Retrocommissioning (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO) | EC2a113        |
| Custom - Motors & VFD (Turnkey)        | C&I Existing Building Retrofit (CI_RETRO) | EC2a053        |
| Custom - Process (Turnkey)             | C&I Existing Building Retrofit (CI_RETRO) | EC2a056        |
| Custom - Refrigeration (Turnkey)       | C&I Existing Building Retrofit (CI_RETRO) | EC2a057        |
| Custom - Other (Turnkey)               | C&I Existing Building Retrofit (CI_RETRO) | EC2a058        |
| Custom - Lighting Systems (Turnkey)    | C&I Existing Building Retrofit (CI_RETRO) | EC2a052        |
| Custom - Lighting Controls (Turnkey)   | C&I Existing Building Retrofit (CI_RETRO) | EC2a121        |
| Building Shell, Gas - Custom (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | GC2a028        |

|                                       |                                           |         |
|---------------------------------------|-------------------------------------------|---------|
| Controls, Gas - Custom (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a029 |
| Foodservice, Gas - Custom (Turnkey)   | C&I Existing Building Retrofit (CI_RETRO) | GC2a030 |
| Heat Recovery, Gas - Custom (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | GC2a031 |
| Heating, Gas - Custom (Turnkey)       | C&I Existing Building Retrofit (CI_RETRO) | GC2a032 |
| Other, Gas - Custom (Turnkey)         | C&I Existing Building Retrofit (CI_RETRO) | GC2a033 |
| Process, Gas - Custom (Turnkey)       | C&I Existing Building Retrofit (CI_RETRO) | GC2a034 |
| Steam Trap, Gas - Custom (Turnkey)    | C&I Existing Building Retrofit (CI_RETRO) | GC2a035 |
| Water Heating, Gas - Custom (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | GC2a036 |
| Retrocomissioning (Turnkey)           | C&I Existing Building Retrofit (CI_RETRO) | GC2a073 |

### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

### Baseline Efficiency:

Custom project baselines should be developed in accordance with the MA Baseline Framework<sup>1</sup> and the MA C&I Baseline Repository. Retrofit projects will use the existing system or performance as the first year savings baseline. Lost opportunity projects will generally refer to code, if applicable, or Industry Standard Practice (ISP), although there may be exceptions. If code does not apply and an ISP is not available, engineering judgement should be used to determine a project baseline.

### High Efficiency:

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

### Measure Life:

For both lost-opportunity and retrofit custom applications, the measure life is determined on a case-by-case basis.<sup>2</sup>

### Other Resource Impacts:

Other resource impacts are determined on a case-by-case basis for custom projects.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                 | Core Initiative | PA           | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------|-----------------|--------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Lighting, Electric           | CI_RETRO        | NGRID        | 1.00 | 0.93            | n/a              | 0.91             | 1.03             | custom           | custom           |
| Refrigeration, Electric      | CI_RETRO        | NGRID        | 1.00 | 1.049           | n/a              | 0.941            | 1.174            | custom           | custom           |
| Other, Electric              | CI_RETRO        | NGRID        | 1.00 | 1.049           | n/a              | 0.941            | 1.174            | custom           | custom           |
| Lighting, Electric           | CI_RETRO        | ES,<br>CLC   | 1.00 | 0.93            | n/a              | 0.91             | 1.03             | custom           | custom           |
| Other Non-Lighting, Electric | CI_RETRO        | ES           | 1.00 | 0.946           | n/a              | 1.265            | 1.415            | custom           | custom           |
| Other Non-Lighting, Electric | CI_RETRO        | CLC          | 1.00 | 1.049           | n/a              | 0.941            | 1.174            | custom           | custom           |
| Lighting, Electric           | CI_RETRO        | Unitil       | 1.00 | 0.93            | n/a              | 0.91             | 1.03             | custom           | custom           |
| Non-Lighting, Electric       | CI_RETRO        | Unitil       | 1.00 | 0.946           | n/a              | 1.265            | 1.415            | custom           | custom           |
| All Custom, Gas              | CI_RETRO        | ES           | 1.00 | n/a             | 0.76             | n/a              | n/a              | n/a              | n/a              |
| All Custom, Gas              | CI_RETRO        | NGRID        | 1.00 | n/a             | 0.87             | n/a              | n/a              | n/a              | n/a              |
| All Custom, Gas              | CI_RETRO        | EGMA         | 1.00 | n/a             | 0.93             | n/a              | n/a              | n/a              | n/a              |
| All Custom, Gas              | CI_RETRO        | All<br>Other | 1.00 | n/a             | 0.80             | n/a              | n/a              | n/a              | n/a              |

### In-Service Rates:

All installations have 100% in-service rates since all PA programs include verification of equipment installations.

### Realization Rates:

- All PAs use lighting results from 2018 small business impact study, which included samples of both custom and prescriptive.<sup>3</sup> All PAs use electric non-lighting results from the 2020 small business impact study, which included samples of both custom and prescriptive.<sup>4</sup>
- Gas RRs: Eversource, National Grid, and EGMA use PA specific results based on evaluation of PY2018 projects, while other PAs use statewide average.<sup>5</sup>

**Coincidence Factors:**

For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

**Impact Factors for Calculating Net Savings:**

Custom net-to-gross values are from the 2021 Omnibus Net-to-Gross Study.<sup>6</sup>

| Measure Name                              | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------|-----------------|-----|-------|-----------------|------------------|------|
| All Custom Gas, Turnkey                   | CI_RETRO        | All | 0.017 | 0.00            | 0.00             | 0.98 |
| All Custom Electric Non-Lighting, Turnkey | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.94 |
| All Custom Electric Lighting, Turnkey     | CI_RETRO        | All | 0.13  | 0.014           | 0.003            | 0.80 |

**Non-Energy Impacts:**

Non-energy impacts are from the 2021 C&I O&M and non-O&M NEI Study<sup>7</sup>.

| Measure                                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual per kWh | One-time \$ per KWh | Annual per therm | One-time \$ per Therm |
|------------------------------------------|-----------------|-----|--------------------|----------------------|----------------|---------------------|------------------|-----------------------|
| Building Shell, Gas - Custom (Turnkey)   | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.483         | n/a                   |
| Faucet Aerator, Gas (Turnkey)            | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.357         | n/a                   |
| Low-Flow Showerhead, Gas (Turnkey)       | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.357         | n/a                   |
| Steam Trap, Gas - Custom (Turnkey)       | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.349         | n/a                   |
| Water Heating, Gas - Custom (Turnkey)    | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.349         | n/a                   |
| Steam Trap, Gas - (Turnkey)              | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.080         | n/a                   |
| Steam Trap, Gas - Prescriptive (Turnkey) | CI_RETRO        | All | n/a                | n/a                  | \$ -           | n/a                 | \$ 0.080         | n/a                   |

|                                                   |          |     |     |     |          |     |            |     |
|---------------------------------------------------|----------|-----|-----|-----|----------|-----|------------|-----|
| Steam Trap, Gas (Turnkey)                         | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.080   | n/a |
| HVAC - Custom (Turnkey)                           | CI_RETRO | All | n/a | n/a | \$ 0.051 | n/a | \$ -       | n/a |
| Programmable Thermostats (Turnkey)                | CI_RETRO | All | n/a | n/a | \$ 0.247 | n/a | \$ -       | n/a |
| Programmable Thermostat, Gas (Turnkey)            | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 2.800   | n/a |
| Wi-Fi Thermostat, Gas (Turnkey)                   | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 2.800   | n/a |
| Duct Sealing, Gas (Turnkey)                       | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.593   | n/a |
| Duct Insulation, Gas (Turnkey)                    | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.593   | n/a |
| Energy Management System (Turnkey)                | CI_RETRO | All | n/a | n/a | \$ 0.222 | n/a | \$ -       | n/a |
| Controls, Gas - Custom (Turnkey)                  | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ (0.037) | n/a |
| Heat Recovery, Gas - Custom (Turnkey)             | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ (0.037) | n/a |
| Heating, Gas - Custom (Turnkey)                   | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ (0.037) | n/a |
| Pipe Wrap (Water Heating), Gas , <=1.5" (Turnkey) | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.863   | n/a |
| Pipe Wrap (Water Heating), Gas , 2" (Turnkey)     | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.863   | n/a |



|                                                     |          |     |     |     |          |     |          |     |
|-----------------------------------------------------|----------|-----|-----|-----|----------|-----|----------|-----|
| Pipe Wrap<br>Steam, Gas ,<br><=1.5"<br>(Turnkey)    | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.863 | n/a |
| Pipe Wrap<br>Steam, Gas , 3"<br>(Turnkey)           | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.863 | n/a |
| Boiler Reset<br>Control<br>(Turnkey)                | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.863 | n/a |
| Lighting<br>Controls -<br>Interior<br>(Turnkey)     | CI_RETRO | All | n/a | n/a | \$ 0.127 | n/a | \$ -     | n/a |
| Lighting<br>Controls -<br>Exterior<br>(Turnkey)     | CI_RETRO | All | n/a | n/a | \$ 0.127 | n/a | \$ -     | n/a |
| Compressed<br>Air - Custom<br>(Turnkey)             | CI_RETRO | All | n/a | n/a | \$ 0.018 | n/a | \$ -     | n/a |
| Motors & VFD<br>- Custom<br>(Turnkey)               | CI_RETRO | All | n/a | n/a | \$ 0.018 | n/a | \$ -     | n/a |
| VFD -<br>Prescriptive<br>(Turnkey)                  | CI_RETRO | All | n/a | n/a | \$ 0.002 | n/a | \$ -     | n/a |
| VFD with<br>Motor -<br>Prescriptive<br>(Turnkey)    | CI_RETRO | All | n/a | n/a | \$ 0.002 | n/a | \$ -     | n/a |
| Retrocomission<br>ing (Turnkey)                     | CI_RETRO | All | n/a | n/a | \$ 0.283 | n/a | \$ -     | n/a |
| Retrocomission<br>ing (Turnkey)                     | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 1.439 | n/a |
| Retrocomission<br>ing, Gas -<br>Custom<br>(Turnkey) | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.153 | n/a |

|                                       |          |     |     |     |          |     |            |     |
|---------------------------------------|----------|-----|-----|-----|----------|-----|------------|-----|
| Refrigeration - Custom (Turnkey)      | CI_RETRO | All | n/a | n/a | \$ 0.077 | n/a | \$ -       | n/a |
| Other - Custom (Turnkey)              | CI_RETRO | All | n/a | n/a | \$ 0.065 | n/a | \$ -       | n/a |
| Other, Gas - Custom (Turnkey)         | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.607   | n/a |
| Hot Water - Custom (Turnkey)          | CI_RETRO | All | n/a | n/a | \$ 0.065 | n/a | \$ -       | n/a |
| Lighting Systems - Interior (Turnkey) | CI_RETRO | All | n/a | n/a | \$ 0.048 | n/a | \$ -       | n/a |
| Lighting Systems - Exterior (Turnkey) | CI_RETRO | All | n/a | n/a | \$ 0.048 | n/a | \$ -       | n/a |
| Lighting - Custom (Turnkey)           | CI_RETRO | All | n/a | n/a | \$ 0.095 | n/a | \$ -       | n/a |
| Process - Custom (Turnkey)            | CI_RETRO | All | n/a | n/a | \$ 0.098 | n/a | \$ -       | n/a |
| Food Services, Gas - Custom (Turnkey) | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 3.399   | n/a |
| Process, Gas - Custom (Turnkey)       | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ (0.045) | n/a |
| Pre-Rinse Spray Valve (Turnkey)       | CI_RETRO | All | n/a | n/a | \$ -     | n/a | \$ 0.357   | n/a |

**Endnotes:**

1: DNV GL (2017). Massachusetts Commercial Industrial Baseline Framework.

[2017 DNVGL MA Baseline Framework](#)

2: Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

3: DNV GL (2018). Impact Evaluation of Small Business Lighting Measured (Phase I).

4: DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.

5: [2020 DNVGL Custom Gas Final Report](#)

**6:** NMR Group, Inc., DNV, and Tetra Tech (2021). C&I Prescriptive and Custom Net-to-Gross Omnibus Study.

**7:** NMR Group Inc. (2021). C&I O&M and non-O&M NEI Study.

### 3.13. Custom - Large C&I

|                     |              |
|---------------------|--------------|
| <b>Measure Code</b> | COM-CM-CMLCI |
| <b>Market</b>       | Commercial   |
| <b>Program Type</b> | Custom       |
| <b>Category</b>     | Custom       |

#### Measure Description:

The Custom project track is offered for gas and electric energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.

#### BCR Measure IDs:

| Measure Name                             | Core Initiative                                  | BCR Measure ID |
|------------------------------------------|--------------------------------------------------|----------------|
| Custom - CHP                             | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a028        |
| Custom - Fuel Cell                       | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a054        |
| Custom - Comprehensive Design (Legacy)   | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a001        |
| Custom - Zero Net Energy Design Approach | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a065        |
| Custom - Whole Building EUI Approach     | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a066        |
| Custom - Modeled Approach                | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a067        |
| Custom - Compressed Air                  | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a002        |
| Custom - HVAC                            | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a010        |
| Custom - Envelope                        | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a064        |
| Custom - Lighting Systems                | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a013        |

|                                                  |                                                  |         |
|--------------------------------------------------|--------------------------------------------------|---------|
| Custom - Lighting Controls                       | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a055 |
| Custom - Indoor Agriculture                      | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a068 |
| Custom - Motors & VFD                            | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a024 |
| Custom - Process                                 | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a026 |
| Custom - Refrigeration                           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a027 |
| Custom - Water Heating                           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a009 |
| Custom - Other                                   | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a029 |
| Compressed Air - High Efficiency Air Compressors | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a003 |
| Custom - CHP                                     | C&I Existing Building Retrofit (CI_RETRO)        | EC2a001 |
| Custom - Fuel Cell                               | C&I Existing Building Retrofit (CI_RETRO)        | EC2a119 |
| Custom - Comprehensive Retrofit                  | C&I Existing Building Retrofit (CI_RETRO)        | EC2a002 |
| Custom - Compressed Air                          | C&I Existing Building Retrofit (CI_RETRO)        | EC2a003 |
| Custom - HVAC                                    | C&I Existing Building Retrofit (CI_RETRO)        | EC2a007 |
| Custom - HVAC (Fuel Switching)                   | C&I Existing Building Retrofit (CI_RETRO)        | EC2a115 |
| Custom - Envelope                                | C&I Existing Building Retrofit (CI_RETRO)        | EC2a124 |
| Custom - Retrocommissioning                      | C&I Existing Building Retrofit (CI_RETRO)        | EC2a114 |
| Custom - Lighting Systems                        | C&I Existing Building Retrofit (CI_RETRO)        | EC2a008 |
| Custom - Lighting Controls                       | C&I Existing Building Retrofit (CI_RETRO)        | EC2a120 |

|                                                  |                                            |         |
|--------------------------------------------------|--------------------------------------------|---------|
| Custom - Indoor Agriculture                      | C&I Existing Building Retrofit (CI_RETRO)  | EC2a151 |
| Custom - Motors & VFD                            | C&I Existing Building Retrofit (CI_RETRO)  | EC2a019 |
| Custom - Process                                 | C&I Existing Building Retrofit (CI_RETRO)  | EC2a024 |
| Custom - Refrigeration                           | C&I Existing Building Retrofit (CI_RETRO)  | EC2a025 |
| Custom - Water Heating                           | C&I Existing Building Retrofit (CI_RETRO)  | EC2a026 |
| Custom - Other                                   | C&I Existing Building Retrofit (CI_RETRO)  | EC2a027 |
| Custom - Lighting Controls (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO)  | EC2a122 |
| Custom - CHP                                     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b001 |
| Custom - Fuel Cell                               | C&I New & Replacement Equipment (CI_EQUIP) | EC2b093 |
| Custom - Compressed Air                          | C&I New & Replacement Equipment (CI_EQUIP) | EC2b002 |
| Custom - HVAC                                    | C&I New & Replacement Equipment (CI_EQUIP) | EC2b009 |
| Custom - Motors & VFD                            | C&I New & Replacement Equipment (CI_EQUIP) | EC2b023 |
| Custom - Refrigeration                           | C&I New & Replacement Equipment (CI_EQUIP) | EC2b026 |
| Custom - Water Heating                           | C&I New & Replacement Equipment (CI_EQUIP) | EC2b027 |
| Custom - Process                                 | C&I New & Replacement Equipment (CI_EQUIP) | EC2b025 |
| Custom - Other                                   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b028 |
| Custom - Lighting Systems                        | C&I New & Replacement Equipment (CI_EQUIP) | EC2b012 |
| Custom - Lighting Controls                       | C&I New & Replacement Equipment (CI_EQUIP) | EC2b094 |

|                                    |                                                  |         |
|------------------------------------|--------------------------------------------------|---------|
| Building Shell, Gas - Custom       | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a001 |
| Comprehensive Design, Gas - Custom | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a002 |
| Controls, Gas - Custom             | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a003 |
| Foodservice, Gas - Custom          | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a004 |
| Heat Recovery, Gas - Custom        | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a005 |
| Heating, Gas - Custom              | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a006 |
| Other, Gas - Custom                | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a007 |
| Process, Gas - Custom              | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a009 |
| Water Heating, Gas - Custom        | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a010 |
| Building Shell, Gas - Custom       | C&I Existing Building Retrofit (CI_RETRO)        | GC2a003 |
| Controls, Gas - Custom             | C&I Existing Building Retrofit (CI_RETRO)        | GC2a004 |
| Foodservice, Gas - Custom          | C&I Existing Building Retrofit (CI_RETRO)        | GC2a005 |
| Heat Recovery, Gas - Custom        | C&I Existing Building Retrofit (CI_RETRO)        | GC2a006 |
| Heating, Gas - Custom              | C&I Existing Building Retrofit (CI_RETRO)        | GC2a007 |
| Other, Gas - Custom                | C&I Existing Building Retrofit (CI_RETRO)        | GC2a008 |
| Ozonated Laundry, Gas - Custom     | C&I Existing Building Retrofit (CI_RETRO)        | GC2a009 |
| Process, Gas - Custom              | C&I Existing Building Retrofit (CI_RETRO)        | GC2a010 |
| Steam Trap, Gas - Custom           | C&I Existing Building Retrofit (CI_RETRO)        | GC2a011 |

|                                          |                                                  |         |
|------------------------------------------|--------------------------------------------------|---------|
| Water Heating, Gas - Custom              | C&I Existing Building Retrofit (CI_RETRO)        | GC2a014 |
| Retrocommissioning, Gas - Custom         | C&I Existing Building Retrofit (CI_RETRO)        | GC2a072 |
| Steam Trap, Gas (Turnkey)                | C&I Existing Building Retrofit (CI_RETRO)        | GC2a071 |
| Foodservice, Gas - Custom                | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b001 |
| Heat Recovery, Gas - Custom              | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b002 |
| Heating, Gas - Custom                    | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b003 |
| Other, Gas - Custom                      | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b004 |
| Process, Gas - Custom                    | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b005 |
| Water Heating, Gas - Custom              | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b006 |
| Custom - Zero Net Energy Design Approach | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a044 |
| Custom - Whole Building EUI Approach     | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a045 |
| Custom - Modeled Approach                | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a046 |
| Custom - HVAC (Electrification)          | C&I Existing Building Retrofit (CI_RETRO)        | GC2a075 |

### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

### Baseline Efficiency:

Custom project baselines should be developed in accordance with the MA Baseline Framework<sup>1</sup> and the MA C&I Baseline Repository. Retrofit projects will use the existing system or performance as the first year savings baseline. Lost opportunity projects will generally refer to code, if applicable, or Industry Standard Practice (ISP), although there may be exceptions. If code does not apply and an ISP is not available, engineering judgement should be used to determine a project baseline.



### High Efficiency:

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

### Measure Life:

For both lost-opportunity and retrofit custom applications, the measure life is determined on a case-by-case basis. Dual baseline effects should be considered for retrofit projects.<sup>3</sup>

The Custom Screening Tool drop-down menus provide the following Effective Useful Life (EUL) options for custom measures:

| Measure Type                                              | EUL Options in Custom Screening Tool |
|-----------------------------------------------------------|--------------------------------------|
| Boiler, HVAC                                              | 5, 10, 15, 20, 25                    |
| Boiler, non-HVAC                                          | 5, 10, 15, 20, 25                    |
| Building Shell                                            | 5, 10, 15, 20, 25                    |
| Chillers                                                  | 23                                   |
| Combined Heat & Power                                     | 5, 10, 15, 20, 25                    |
| Comprehensive Retrofit                                    | 5-25                                 |
| Compressed Air                                            | 13                                   |
| Compressed Air Equipment (Compressors, Dryers, ZL drains) | 15                                   |
| Compressed Air Equipment and Systems                      | 15                                   |
| Cooling Equipment                                         | 15                                   |
| EMS / controls, HVAC                                      | 5, 10, 13, 15                        |
| EMS / controls, non-HVAC                                  | 5, 10, 13, 15                        |
| Equipment Insulation, HVAC                                | 10, 15, 20                           |
| Equipment Insulation, non-HVAC                            | 10, 15, 20                           |
| Food Service                                              | 10, 12, 15                           |
| Fuel switching, HVAC                                      | 5, 10, 15, 20, 25                    |
| Fuel switching, non-HVAC                                  | 5, 10, 15, 20, 25                    |

|                                          |                       |
|------------------------------------------|-----------------------|
| Furnace, HVAC                            | 18                    |
| Furnace, non-HVAC                        | 18                    |
| Heat recovery, HVAC                      | 10, 15, 20            |
| Heat recovery, non-HVAC                  | 10, 15, 20            |
| High Efficiency Motor                    | 20                    |
| HVAC                                     | 13                    |
| HVAC Equipment and Systems               | 15                    |
| Integrated Design Project                | 5-25                  |
| Lighting                                 | 13                    |
| Lighting - Exterior                      | 15                    |
| Lighting - Exterior Controls             | 9, 10                 |
| Lighting - Exterior with Controls        | 15                    |
| Lighting - Interior                      | 15                    |
| Lighting - Interior Controls             | 9, 10                 |
| Lighting - Interior with Controls        | 15                    |
| Motors/Drive HVAC                        | 13                    |
| Motors/Drive Non-HVAC                    | 13                    |
| O&M (leak repair, filter retrofit), CAIR | 2, 5                  |
| O&M / Retrocommissioning, HVAC           | 1-5                   |
| O&M / Retrocommissioning, non-HVAC       | 1-5                   |
| Other                                    | 5-25                  |
| Other, HVAC                              | 5, 10, 15, 20, 25     |
| Other, non-HVAC                          | 10, 15, 20, 25        |
| Process                                  | 1-13                  |
| Process Equipment                        | 5, 10, 13, 15, 18, 20 |
| Process Equipment and Controls           | 5, 10                 |
| Refrigeration                            | 13                    |

|                            |               |
|----------------------------|---------------|
| Refrigeration, Commercial  | 15            |
| Refrigeration, Industrial  | 20            |
| Steam trap, HVAC           | 6             |
| Steam trap, non-HVAC       | 6             |
| Transformer Replacement    | 20, 25        |
| Verified savings, HVAC     | 10, 15        |
| Verified savings, non-HVAC | 10, 15        |
| VFD on HVAC Equipment      | 15            |
| VFD on non-HVAC Equipment  | 15            |
| Water heating, DHW         | 5, 10, 13, 15 |

**Other Resource Impacts:**

Other resource impacts should be determined on a case by case basis for custom projects.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative               | PA                                     | ISR | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> | LSAFE | LSAFNE |
|-------------------------------|-------------------------------|----------------------------------------|-----|-----------------|------------------|------------------|------------------|------------------|------------------|-------|--------|
| Custom Gas, All               | CI_NB&MR, CI_RETRO, CI_IP&EUL | NGRID                                  | 1   | n/a             | 0.87             | n/a              | n/a              | custom           | custom           | n/a   | 1.02   |
|                               |                               | Statewide - Eversource                 | 1   | n/a             | 0.76             | n/a              | n/a              | custom           | custom           | n/a   | 1.03   |
|                               |                               | EGMA                                   | 1   | n/a             | 0.93             | n/a              | n/a              | custom           | custom           | n/a   | 1.08   |
|                               |                               | Statewide - Unitil, Liberty, Berkshire | 1   | n/a             | 0.8              | n/a              | n/a              | custom           | custom           | n/a   | 1.03   |
| Custom Electric, Non-Lighting | CI_NB&MR, CI_RETRO, CI_IP&EUL | NGRID                                  | 1   | 0.69            | 0.69             | 0.74             | 0.62             | custom           | custom           | 1.01  | 1.01   |
|                               |                               | Eversource                             | 1   | 0.77            | 0.77             | 0.87             | 0.87             | custom           | custom           | 1.03  | 1.03   |
|                               |                               | CLC                                    | 1   | 0.88            | 0.88             | 0.81             | 0.98             | custom           | custom           | 0.97  | 0.97   |
|                               |                               | Unitil (Statewide)                     | 1   | 0.75            | 0.75             | 0.8              | 0.74             | custom           | custom           | 1.01  | 1.01   |

|                                                     |                               |                    |   |      |      |      |      |        |        |      |      |
|-----------------------------------------------------|-------------------------------|--------------------|---|------|------|------|------|--------|--------|------|------|
| Custom Electric, Lighting                           | CI_NB&MR, CI_RETRO, CI_IP&EUL | NGRID              | 1 | 0.99 | 0.99 | 1.04 | 0.91 | custom | custom | 1    | 1    |
|                                                     |                               | Eversource         | 1 | 1.01 | 1.01 | 0.94 | 0.79 | custom | custom | 0.96 | 0.96 |
|                                                     |                               | CLC                | 1 | 0.94 | 0.94 | 1.35 | 1.06 | custom | custom | 0.86 | 0.86 |
|                                                     |                               | Unitil (Statewide) | 1 | 1    | 1    | 1    | 0.84 | custom | custom | 0.98 | 0.98 |
| Custom - Comprehensive Design (Legacy) - Electric   | CI_NB&MR                      | All                | 1 | 0.57 | 0.57 | 0.57 | 0.43 | custom | custom | n/a  | n/a  |
| Custom - Comprehensive Design (Legacy) - Gas        | CI_NB&MR                      | All                | 1 | n/a  | 1.01 | n/a  | n/a  | custom | custom | n/a  | n/a  |
| Custom - Zero Net Energy Design Approach - Electric | CI_NB&MR                      | All                | 1 | 0.94 | 0.94 | 0.57 | 0.43 | custom | custom | n/a  | n/a  |
| Custom - Zero Net Energy Design Approach - Gas      | CI_NB&MR                      | All                | 1 | n/a  | 0.97 | n/a  | n/a  | custom | custom | n/a  | n/a  |
| Custom - Whole Building EUI Approach - Electric     | CI_NB&MR                      | All                | 1 | 0.94 | 0.94 | 0.57 | 0.43 | custom | custom | n/a  | n/a  |
| Custom - Whole Building EUI Approach - Gas          | CI_NB&MR                      | All                | 1 | n/a  | 0.97 | n/a  | n/a  | custom | custom | n/a  | n/a  |
| Custom - Modeled                                    | CI_NB&MR                      | All                | 1 | 0.57 | 0.57 | 0.57 | 0.43 | custom | custom | n/a  | n/a  |

|                                 |                               |            |   |      |      |      |      |        |        |     |     |
|---------------------------------|-------------------------------|------------|---|------|------|------|------|--------|--------|-----|-----|
| Approach - Electric             |                               |            |   |      |      |      |      |        |        |     |     |
| Custom - Modeled Approach - Gas | CI_NB&MR                      | All        | 1 | n/a  | 1.01 | n/a  | n/a  | custom | custom | n/a | n/a |
| CHP - Custom                    | CI_NB&MR, CI_RETRO, CI_IP&EUL | Eversource | 1 | 1.1  | 1.22 | 1.44 | 1.01 | custom | custom | n/a | n/a |
|                                 |                               | NGRID      | 1 | 0.91 | 1.02 | 1.09 | 1.05 | custom | custom | n/a | n/a |
|                                 |                               | Unitil     | 1 | 0.9  | 1.12 | 1.26 | 1.58 | custom | custom | n/a | n/a |

In-Service Rates:

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

Realization Rates:

- CHP - Custom: RRs based on evaluation of PY 2012 projects<sup>4</sup>. Unitil uses statewide results given their small sample size. Note that RR<sub>NE</sub> applies to project fossil fuel penalty.
- Comprehensive Design Analysis, Electric and Gas: For Legacy programs and Modeled Approach: gas RRs based on evaluation of PY2014 projects<sup>5</sup>; electric RRs based on 2021 analysis<sup>6</sup>. For Zero Net Energy and Whole Building EUI programs, realization rates are based on negotiated values; all other values are identical to Legacy values.
- Electric, Lighting & Non-Lighting: RRs based on evaluation of PY2018-PY2019 projects.<sup>7</sup>
- Gas (all): RRs based on evaluation of PY2018 projects.<sup>8</sup>

Coincidence Factors:

For all PAs, gross summer and winter peak coincidence factors are custom-calculated for each custom project based on project-specific information. The actual or measured coincidence factors are included in the summer and winter demand realization rates.

**Impact Factors for Calculating Net Savings:**

Net-to-gross values for Custom Gas and Custom Electric are taken from the 2021 C&I Omnibus NTG Study.<sup>8</sup>

Net-to-gross values for the Custom New Buildings & Major Renovations programs are taken from the 2021 Non-Residential New Construction Net-to-Gross Study.<sup>10</sup>

| Measure Name | Core Initiative | PA | FR | SO <sub>P</sub> | SO <sub>NP</sub> | NTG |
|--------------|-----------------|----|----|-----------------|------------------|-----|
|--------------|-----------------|----|----|-----------------|------------------|-----|

|                                          |          |     |        |        |       |         |
|------------------------------------------|----------|-----|--------|--------|-------|---------|
| Custom Electric - Non-Lighting           | CI_NB&MR | All | 58.30% | 22.70% | n/a   | 64.40%  |
|                                          | CI_EQUIP | All | 38.20% | 0.00%  | 2.40% | 64.20%  |
|                                          | CI_RETRO | All | 17.10% | 1.60%  | 7.70% | 102.00% |
| All Custom Electric - Lighting           | CI_NB&MR | All | 58.30% | 22.70% | n/a   | 64.40%  |
|                                          | CI_EQUIP | All | 38.20% | 0.00%  | 2.40% | 64.20%  |
|                                          | CI_RETRO | All | 43.50% | 1.60%  | 7.70% | 65.80%  |
| All Custom Gas                           | CI_NB&MR | All | 58.30% | 22.70% | n/a   | 64.40%  |
|                                          | CI_EQUIP | All | 5.10%  | 0.10%  | 0.00% | 95.00%  |
|                                          | CI_RETRO | All | 19.60% | 0.20%  | 0.00% | 80.60%  |
| Custom - Comprehensive Design (Legacy)   | CI_NB&MR | All | 58.30% | 22.70% | n/a   | 64.40%  |
| Custom - Zero Net Energy Design Approach | CI_NB&MR | All | n/a    | n/a    | n/a   | 73%     |
| Custom - Whole Building EUI Approach     | CI_NB&MR | All | n/a    | n/a    | n/a   | 73%     |
| Custom - Modeled Approach                | CI_NB&MR | All | 58.30% | 22.70% | n/a   | 64.40%  |

### Non-Energy Impacts:

All non-energy impacts should be determined on a case-by-case basis. Default NEIs are provided in the table below for retrofit and new building applications. NEIs were updated in 2021 via the C&I O&M and non-O&M NEI Study<sup>NMR, 2021</sup>. C&I O&M and non-O&M NEI Study.<sup>11</sup>

| Measure Name           | Core Initiative    | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------|--------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Building Shell         | CI_NB&MR, CI_RETRO | All |                    |                      | \$0.157           |                     | \$0.483             |                       |
| Comprehensive Design   | CI_NB&MR           | All |                    |                      | \$0.015           |                     | \$0.483             |                       |
| Compressed Air         | CI_NB&MR           | All |                    |                      | \$0.030           |                     | \$0.348             |                       |
| Controls, Gas          | CI_NB&MR           | All |                    |                      | n/a               |                     | (\$0.054)           |                       |
| Food Service           | CI_NB&MR, CI_EQUIP | All |                    |                      | \$0.051           |                     | \$3.40              |                       |
| Heat Recovery, Gas     | CI_NB&MR           | All |                    |                      | n/a               |                     | (\$0.037)           |                       |
| HVAC                   | CI_NB&MR           | All |                    |                      | \$0.003           |                     | (\$0.037)           |                       |
| Lighting               | CI_NB&MR           | All |                    |                      | \$0.018           |                     | n/a                 |                       |
| Motors & VFD           | CI_NB&MR           | All |                    |                      | \$0.018           |                     | n/a                 |                       |
| Other                  | CI_NB&MR           | All |                    |                      | \$0.070           |                     | n/a                 |                       |
| Process                | CI_NB&MR           | All |                    |                      | \$0.013           |                     | \$0.607             |                       |
| Process, Gas           | CI_NB&MR           | All |                    |                      | \$0.091           |                     | (\$0.045)           |                       |
| Refrigeration          | CI_NB&MR           | All |                    |                      | \$0.098           |                     | n/a                 |                       |
| Boilers                | CI_NB&MR           | All |                    |                      | n/a               |                     | (\$0.037)           |                       |
| Water Heating          | CI_NB&MR           | All |                    |                      | \$0.101           |                     | \$0.00              |                       |
| Water Heating, Gas     | CI_NB&MR           | All |                    |                      | n/a               |                     | \$0.349             |                       |
| Comprehensive Retrofit | CI_RETRO           | All |                    |                      | n/a               |                     | \$0.483             |                       |
| Compressed Air         | CI_RETRO, CI_EQUIP | All |                    |                      | \$0.056           |                     | \$0.349             |                       |
| Controls, Gas          | CI_RETRO           | All |                    |                      | \$0.030           |                     | (\$0.04)            |                       |
| Food Service           | CI_RETRO           | All |                    |                      | \$0.030           |                     | \$3.40              |                       |
| Heat Recovery, Gas     | CI_RETRO           | All |                    |                      | n/a               |                     | (\$0.037)           |                       |
| Heat Recovery, Gas     | CI_EQUIP           |     |                    |                      |                   |                     | (\$0.054)           |                       |
| HVAC                   | CI_RETRO           | All |                    |                      | \$0.024           |                     | (\$0.037)           |                       |
| HVAC                   | CI_EQUIP           | All |                    |                      | \$0.018           |                     | (\$0.054)           |                       |

|                         |                    |     |  |  |           |  |           |  |
|-------------------------|--------------------|-----|--|--|-----------|--|-----------|--|
| HVAC - Fuel Switching   | CI_RETRO           | All |  |  | \$0.018   |  | n/a       |  |
| Lighting                | CI_RETRO, CI_EQUIP | All |  |  | \$0.018   |  | n/a       |  |
| Motors & VFD            | CI_RETRO, CI_EQUIP | All |  |  | n/a       |  | \$0.153   |  |
| Process                 | CI_RETRO           | All |  |  | \$0.056   |  | \$0.607   |  |
| Process                 | CI_EQUIP           | All |  |  | \$0.065   |  | n/a       |  |
| Process, Gas            | CI_RETRO           | All |  |  | \$0.095   |  | (\$0.045) |  |
| Process, Gas            | CI_EQUIP           | All |  |  | \$0.065   |  | (\$0.05)  |  |
| Other                   | CI_RETRO           | All |  |  | \$0.065   |  | n/a       |  |
| Other                   | CI_EQUIP           | All |  |  | \$0.077   |  | n/a       |  |
| Other, Gas              | CI_EQUIP, CI_RETRO | All |  |  | \$0.065   |  | \$0.61    |  |
| Ozonated Laundry, Gas   | CI_RETRO           | All |  |  | n/a       |  | \$0.44    |  |
| Process                 | CI_RETRO           | All |  |  | \$0.095   |  | n/a       |  |
| Refrigeration           | CI_RETRO, CI_EQUIP | All |  |  | \$0.065   |  | n/a       |  |
| Retrocommissioning, Gas | CI_RETRO           | All |  |  | \$0.095   |  | \$1.44    |  |
| CHP                     | CI_RETRO           | All |  |  | \$(0.015) |  | n/a       |  |
| Steam Traps             | CI_RETRO           | All |  |  | \$0.065   |  | \$0.35    |  |
| Water Heating           | CI_RETRO, CI_EQUIP | All |  |  | n/a       |  | \$5.099   |  |
| Water Heating, Gas      | CI_RETRO           | All |  |  | n/a       |  | \$0.349   |  |
| Water Heating, Gas      | CI_EQUIP           | All |  |  | n/a       |  | \$0.35    |  |

**Endnotes:**

**1:** DNV GL (2017). Massachusetts Commercial Industrial Baseline Framework

[2017 DNVGL MA Baseline Framework](#)

**2:** Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.

[2018 DNVGL ERS Portfolio Model Companion Sheet](#)

**4:** KEMA 2013. Massachusetts Combined Heat and Power Program Impact Evaluation, 2011-2012.

[KEMA 2013 MA CI CHP IMPACT EVAL](#)



- 5:** DNV GL (2018). Massachusetts Commercial and Industrial Impact Evaluation of 2014 Custom CDA Installations.
- 8:** Massachusetts C&I Custom CDA Results Memo; DNV GL, March 2021
- 6:** Impact Evaluation of PY2018-2019 Custom Electric Installations, Draft Results Memo. DNV GL (2021)
- 7:** MA C&I Impact Evaluation of PY2018 Custom Gas Installations - Draft Report. DNV GL (2021)
- 8:** C&I Omnibus NTG Study. NMR, 2021. [2021 NMR C&I Omnibus NTG](#)
- 10:** NMR Group, Inc. (2021) Non-Residential New Construction Net-to-Gross Report. NMR, 2021. C&I O&M and non-O&M NEI Study.1: O&M and non-O&M NEI study conducted by NMR, 2021

### 3.14. Other - Small Equipment Electrification

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-HVAC-ELEC    |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | Lost Opportunity |
| <b>Category</b>     | Plug Load        |

#### Measure Description:

Rebates provided for the purchase of battery-powered electric equipment instead of gas or propane equipment.

#### BCR Measure IDs:

| Measure             | Core Initiative                            | BCR Measure ID |
|---------------------|--------------------------------------------|----------------|
| Electric Lawnmower  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b119        |
| Electric Leafblower | C&I New & Replacement Equipment (CI_EQUIP) | EC2b122        |
| Electric Trimmer    | C&I New & Replacement Equipment (CI_EQUIP) | EC2b123        |
| Electric Chainsaw   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b124        |
| Electric Forklift   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b125        |

#### Algorithms for Calculating Primary Energy Impact:

Unit kWh savings are deemed.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name        | Core Initiative | $\Delta$ kWh | $\Delta$ kW |
|---------------------|-----------------|--------------|-------------|
| Electric Lawnmower  | CI_EQUIP        | -218         | -0.23       |
| Electric Leafblower | CI_EQUIP        | -0.78        | 0.00        |
| Electric Trimmer    | CI_EQUIP        | -0.71        | 0.00        |
| Electric Chainsaw   | CI_EQUIP        | -1.02        | 0.00        |
| Electric Forklift   | CI_EQUIP        | -13,886      | -14.62      |

#### Baseline Efficiency:

The baseline efficiency case for electric equipment is gas powered versions of the equipment.

### High Efficiency:

The high efficiency case is electric equipment.

### Measure Life:

The measure life is shown below.<sup>3</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Electric Lawnmower  | CI_EQUIP        | All | 7   | n/a | n/a | 7   |
| Electric Leafblower | CI_EQUIP        | All | 8   | n/a | n/a | 8   |
| Electric Trimmer    | CI_EQUIP        | All | 8   | n/a | n/a | 8   |
| Electric Chainsaw   | CI_EQUIP        | All | 8   | n/a | n/a | 8   |
| Electric Forklift   | CI_EQUIP        | All | 8   | n/a | n/a | 8   |

### Other Resource Impacts:

| Measure Name        | Core Initiative | PA  | Gasoline (MMBTUs) <sup>4</sup> | Propane (MMBTUs) |
|---------------------|-----------------|-----|--------------------------------|------------------|
| Electric Lawnmower  | CI_EQUIP        | All | 2.5                            |                  |
| Electric Leafblower | CI_EQUIP        | All | 1.4                            |                  |
| Electric Trimmer    | CI_EQUIP        | All | 1.4                            |                  |
| Electric Chainsaw   | CI_EQUIP        | All | 1.4                            |                  |
| Electric Forklift   | CI_EQUIP        | All |                                | 137.4            |

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Electric Lawnmower  | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Leafblower | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Trimmer    | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Chainsaw   | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |
| Electric Forklift   | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.55             | 0.00             |

**In-Service Rates:**

The in-service rate is assumed to be 100% absent evaluation.

**Realization Rates:**

The realization rate is assumed to be 100% absent evaluation.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------|-----------------|-----|------|-----------------|------------------|------|
| Electric Lawnmower  | CI_EQUIP        | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Leafblower | CI_EQUIP        | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Trimmer    | CI_EQUIP        | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Chainsaw   | CI_EQUIP        | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Electric Forklift   | CI_EQUIP        | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts for this measure.

**Endnotes:**

- 
- 1 : Vermont Act 56 Tier III Technical Advisory Group 2020 Annual Report
  - 2 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
  - 3 : Vermont Act 56 Tier III Technical Advisory Group 2020 Annual Report
  - 4 : Vermont Act 56 Tier III Technical Advisory Group 2020 Annual Report
  - 5 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)

### 3.15. Demand - Active Demand Reduction

|                     |                        |
|---------------------|------------------------|
| <b>Measure Code</b> | COM-BE-ADR             |
| <b>Market</b>       | Commercial             |
| <b>Program Type</b> | Active Demand Response |
| <b>Category</b>     | Custom                 |

#### Measure Description:

Active Demand Reduction includes C&I Interruptible Load Curtailment, Winter Interruptible Load, Battery Storage Daily Dispatch, Battery Storage Targeted Dispatch Summer, Battery Storage Targeted Dispatch Winter, Technology-Neutral Daily Dispatch, Technology-Neutral Targeted Dispatch, and Custom.

The Interruptible Load Curtailment offering is technology agnostic and provides an incentive for verifiable shedding of load in response to a signal or communication from the Program Administrators coinciding with system peak conditions. Large C&I customers with the ability to control lighting, comfort, and/or process loads can use this demand reduction performance offering to generate revenue by altering their operations a few times per year. The offering focuses on reducing demand during summer peak events, typically targeting fewer than twenty-five hours per summer.

The Winter Interruptible Load offering is similar to Interruptible Load for the summer, except that the goal is to help promote winter resiliency by finding customers that can reduce electric usage during times of high winter system load. The offering focuses on reducing demand during winter peak events, typically targeting up to five hours per winter. Note, winter interruptible load is not included in the 2022-2024 plan.

The Battery Storage Daily Dispatch offering provides pay-for-performance incentives to customers with battery storage that can reduce load on a daily basis. Customers are routinely dispatched to reduce regional peak loads on non-holiday weekdays July - September.

The Battery Storage Targeted Dispatch Summer offering provides pay-for-performance incentives to customers with battery storage that can reduce load during peak events. Customers are dispatched up to eight times during the summer with the goal of reducing regional peak loads, specifically the annual system peak hour.

The Battery Storage Targeted Dispatch Winter offering provides pay-for-performance incentives to customers with battery storage that can reduce load during peak events. Customers are dispatched up to five times during the winter the goal of reducing regional peak loads.

The Technology-Neutral Daily Dispatch offering provides pay-for-performance incentives to customers with technology that can reduce load on a daily basis. Customers are routinely dispatched to reduce regional peak loads on non-holiday weekdays July - September.

The Technology-Neutral Targeted Dispatch offering provides pay-for-performance incentives to customers with technology that can reduce load during peak events. Customers are dispatched up to eight

times during the summer with the goal of reducing regional peak loads with a focus on the annual system peak hour.

Custom Active Demand Reduction is site specific.

**BCR Measure IDs:**

| Measure Name                                                   | Core Initiative                      | BCR Measure ID |
|----------------------------------------------------------------|--------------------------------------|----------------|
| Interruptible Load                                             | C&I Active Demand Reduction (CI_ADR) | EC2c001        |
| Winter Interruptible Load                                      | C&I Active Demand Reduction (CI_ADR) | Not included   |
| Battery Storage Daily Dispatch, discharge (savings) Summer     | C&I Active Demand Reduction (CI_ADR) | EC2c003        |
| Battery Storage Daily Dispatch, charge (consumption) Summer    | C&I Active Demand Reduction (CI_ADR) | EC2c011        |
| Battery Storage Targeted Dispatch, discharge (savings) Summer  | C&I Active Demand Reduction (CI_ADR) | EC2c004        |
| Battery Storage Targeted Dispatch, charge (consumption) Summer | C&I Active Demand Reduction (CI_ADR) | EC2c012        |
| Battery Storage Targeted Dispatch, discharge (savings) Winter  | C&I Active Demand Reduction (CI_ADR) | EC2c005        |
| Battery Storage Targeted Dispatch, charge (consumption) Winter | C&I Active Demand Reduction (CI_ADR) | EC2c013        |
| Technology-Neutral Daily Dispatch, discharge Summer            | C&I Active Demand Reduction (CI_ADR) | EC2c008        |
| Technology-Neutral Targeted Dispatch, discharge Summer         | C&I Active Demand Reduction (CI_ADR) | EC2c015        |
| Custom - ADR                                                   | C&I Active Demand Reduction (CI_ADR) | EC2c006        |

**Algorithms for Calculating Primary Energy Impact:**

The Active Demand Reduction measure generates site-specific demand savings. Savings estimates for these projects are calculated using engineering analysis with project-specific details.

**Baseline Efficiency:**

Baseline conditions will be determined based on technology.

For interruptible load, baseline conditions are based on an adjustment settlement baseline with symmetric, additive adjustment. The symmetrically adjusted settlement baseline is developed based on a pool of the most recent 10 non-holiday weekdays. The baseline shape consists of average load per interval across the eligible days. The baseline is adjusted based on the difference between baseline and facility load in the second hour prior to the event (the baseline adjustment period), and the adjustment can be either to increase or decrease the estimated load reduction (i.e., symmetric adjustment). This adjustment accounts for weather-related and other differences of load magnitude.1

For battery storage, both daily dispatch and targeted dispatch, demand reduction is calculated based on battery load. A baseline value is not directly calculated for storage, instead, the counterfactual is the actual facility load without the battery, which is derived based on the facility load with the battery and the battery load.2 3

For technology-neutral targeted dispatch, the average performance during non-event weekday afternoons is used to calculate the baseline load for events. This analysis method is analogous to the settlement baselines for interruptible load curtailment.4

Custom projects will have a custom baseline.

### High Efficiency:

N/A, Active Demand Reduction does not directly increase efficiency. Interruptible Load does reduce energy consumption by curtailing use, but does not increase efficiency per se. Storage increases energy consumption due to round trip efficiency losses.

### Measure Life:

Because Active Demand Reduction is based on Program Administrators calling demand reduction events each year, the measure life is one year.

| Measure Name                         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------|-----------------|-----|-----|-----|-----|-----|
| All Active Demand Reduction measures | CI_ADR          | All | 1   | n/a | n/a | 1   |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name       | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Interruptible Load | CI_ADR          | National Grid | 1.00 | 0.82            | 1.00             | 0.82             | 1.00             | 1.00             | 0.00             |
| Interruptible Load | CI_ADR          | Unitil        | 1.00 | 0.91            | 1.00             | 0.91             | 1.00             | 1.00             | 0.00             |

|                                                                |        |               |      |      |      |      |      |      |      |
|----------------------------------------------------------------|--------|---------------|------|------|------|------|------|------|------|
| Interruptible Load                                             | CI_ADR | Eversource    | 1.00 | 0.78 | 1.00 | 0.78 | 1.00 | 1.00 | 0.00 |
| Winter Interruptible Load                                      | CI_ADR | National Grid | 1.00 | 0.66 | 1.00 | 0.66 | 1.00 | 0.00 | 1.00 |
| Winter Interruptible Load                                      | CI_ADR | CLC           | 1.00 | 0.65 | 1.00 | 0.65 | 1.00 | 0.00 | 1.00 |
| Winter Interruptible Load                                      | CI_ADR | Eversource    | 1.00 | 0.71 | 1.00 | 0.71 | 1.00 | 0.00 | 1.00 |
| Battery Storage Daily Dispatch, discharge (savings) Summer     | CI_ADR | All           | 1.00 | 1.04 | 1.00 | 1.04 | 1.00 | 1.00 | 0.00 |
| Battery Storage Daily Dispatch, charge (consumption) Summer    | CI_ADR | All           | 1.00 | 1.04 | 1.00 | 1.04 | 1.00 | 0.00 | 0.00 |
| Battery Storage Targeted Dispatch, discharge (savings) Summer  | CI_ADR | All           | 1.00 | 1.01 | 1.00 | 1.01 | 1.00 | 1.00 | 0.00 |
| Battery Storage Targeted Dispatch, charge (consumption) Summer | CI_ADR | All           | 1.00 | 1.01 | 1.00 | 1.01 | 1.00 | 0.00 | 0.00 |
| Battery Storage Targeted Dispatch, discharge (savings) Winter  | CI_ADR | All           | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 |
| Battery Storage Targeted Dispatch, charge (consumption) Winter | CI_ADR | All           | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Technology-Neutral Daily Dispatch                              | CI_ADR | All           | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Technology-Neutral Targeted Dispatch                           | CI_ADR | All           | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Custom                                                         | CI_ADR | All           | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 |

**In- Service Rates:**

In-service rates are assumed to be 1.00 until evaluated.

**Realization Rates:**

For summer and winter interruptible load, the peak realization rate is based on the average demand reduction calculated using the evaluated symmetric baseline, divided by the average demand reduction calculated using the reported asymmetric baseline. This rate is what evaluators believe to be most representative of the ratio of evaluated to reported performance.<sup>5</sup>



For battery storage daily dispatch, the summer peak realization rate is calculated as the evaluated average load reduction during the dispatch periods as a percentage of the reported load reduction reported as the prospective realization rate.<sup>6</sup>

For battery storage targeted dispatch, summer and winter, the peak realization rate is calculated as the evaluated average utility event load reduction as a percentage of the reported load reduction.<sup>7</sup>  
 The realization rate for electric kWh (RRE) is assumed to be equal to RRSP.

Unless otherwise noted, realization rates and offerings that have not yet been evaluated at all are listed with a realization rate of 1.0 until evaluation results become available.

**Coincidence Factors:**

Coincidence factors are set to 1.00 until evaluated.

**Impact Factors for Calculating Net Savings:**

Statewide Active Demand Reduction offerings are new in 2019 and have not yet been evaluated with regard to net-to-gross ratios. Net-to-gross ratios are assumed to be 1.0 until the statewide program is evaluated.

| Measure Name                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| All Active Demand Reduction measures | CI_ADR          | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

**5:** ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report [2019 ERS Cross-State CI DR Evaluation](#)

**6:** ERS (2020). Daily Dispatch Battery Project Evaluation Report. [2019 ERS Daily Dispatch Battery](#)

**7:** ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report. [2019 ERS Cross-State CI DR Evaluation](#)

### 3.16. Food Service - Conveyor Broiler

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CB                                       |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of an energy efficient underfired broiler to replace a conventional automatic constant input rate conveyor broiler. This measure has both electric and gas savings.

#### BCR Measure IDs:

| Measure Name                              | Core Initiative                            | BCR Measure ID |
|-------------------------------------------|--------------------------------------------|----------------|
| Midstream - Conveyor Broiler              | C&I New & Replacement Equipment (CI_EQUIP) | EC2b097        |
| Foodservice, Conveyor Broiler - Midstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b057        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the SoCalGas Commercial Conveyor Broilers workpaper WPSCGNRCC171226A.<sup>1</sup>

#### Energy Savings for Conveyor Broiler

| Conveyor Size | $\Delta$ kWh | $\Delta$ therms |
|---------------|--------------|-----------------|
| <22"          | 7,144        | 1,145           |
| 22-28"        | 6,403        | 1,933           |
| >28"          | 23,849       | 3,161           |

#### Baseline Efficiency:

Baseline broiler must be an automatic conveyor broiler capable of maintaining a temperature above 600 F with a tested idle rate greater than:

- 40 kBtu/h for a belt narrower than 22"
- 60 kBtu/h for a belt between 22 and 28"
- 70 kBtu/h for a belt wider than 28"

**High Efficiency:**

The high efficiency case for a conveyor broiler must have a catalyst and an input rate less than 80 kBtu/h or a dual stage or modulating gas valve with a capability of throttling the input rate below 80 kBtu/h. Baseline broiler must be replaced by a broiler similar in size or smaller. Must be installed under a Type II Hood.

**Measure Life:**

The measure life for a new conveyor broiler is 12 years.<sup>2</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Conveyor Broiler | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure          | Core Initiative | PA  | ISR  | SPF  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Conveyor Broiler | CI_EQUIP        | All | 1.00 | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to gross results.<sup>3</sup>

| Measure                    | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|----------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Conveyor Broiler, Electric | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |
| Conveyor Broiler, Gas      | CI_EQUIP        | All | 37.3% | 2.6%            | 19.1%            | 84.4% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results.

| Measure Name               | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Conveyor Broiler, Electric | CI_EQUIP        | ALL | \$0.00             | \$0.00               | \$0.00            | \$0.007             | \$0.00              | \$0.00                |
| Conveyor Broiler, Gas      | CI_EQUIP        | ALL | \$0.00             | \$0.00               | \$0.00            | \$0.00              | \$5.10              | \$0.00                |

**Endnotes:**

- 1:** SoCalGas Commercial Conveyor Broilers workpaper WPCG NRCC171226A11, December 27, 2017.  
**3:** NMR Group, Inc. (2021) Prescriptive and Custom Net-to-Gross Omnibus Study  
[2021\\_NMR\\_C&I\\_Omnibus\\_NTG](#)

### 3.17. Food Service - Electric Fryer

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-CE-CF                                        |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® standard or large vat commercial fryer. ENERGY STAR® commercial fryers save energy during cooking and idle times due to improved cooking efficiency and idle energy rates.

#### BCR Measure IDs:

| Measure Name                                 | Core Initiative                            | BCR Measure ID |
|----------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Commercial Fryer, Standard Vat | C&I New & Replacement Equipment (CI_EQUIP) | EC2b046        |
| Midstream - Commercial Fryer, Standard Vat   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b082        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Calculator:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kWh / \text{Hours}$$

Where:

$\Delta kWh$  = gross annual kWh savings from the measure per table below

$\Delta kW$  = gross average kW savings from the measure per table below

Hours = Annual hours of operation. See Hours section below.

#### Energy Savings for Commercial Fryer<sup>1</sup>

| Equipment Type            | $\Delta kW$ | $\Delta kWh$ |
|---------------------------|-------------|--------------|
| Commercial Fryer - Tier 1 | 0.26        | 1,148        |
| Commercial Fryer - Tier 2 | 0.57        | 2,490        |

#### Baseline Efficiency:

The baseline efficiency case for a Tier 1 electric fryer 78%, and idle energy rate of 1.1 kW.

Tier 2 78% cooking efficiency, 1.1 kW idle rate<sup>2</sup>

The baseline efficiencies represent the mid-point between the new Massachusetts Appliance Standard minimum threshold (50%) and the current year baseline efficiency (35%). MA State Appliance standards signed 3/26/21 starting on page 27 references what the product must meet.<sup>3</sup>

**High Efficiency:**

The high efficiency case for a Tier 1 electric fryer  $\geq 85\%$ , and idle energy rate of  $\leq 0.86$  kW. Tier 2  $\geq 86\%$  cooking efficiency,  $\leq 0.75$  kW idle rate

**Measure Life:**

Measure Life is based on the Energy Star Calculator <sup>4</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Commercial Fryer | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure          | Core Initiative | PA  | ISR  | SPF  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Commercial Fryer | CI_EQUIP        | All | 1.00 | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to gross results<sup>5</sup>

| Measure          | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|------------------|-----------------|-----|------|-----------------|------------------|-------|
| Commercial Fryer | CI_EQUIP        | All | 0.25 | 0.085           | 0.002            | 0.837 |

**Non-Energy Impacts:**

Non-energy impacts are based on study results.

| Measure Name     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Commercial Fryer | CI_EQUIP        | All | \$0.00             | \$0.00               | \$0.007           | \$0.00              | \$0.00              | \$0.00                |

**Endnotes:**

**1:** [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
 August 27, 2021

**2:**

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
 August 27, 2021

**3:** [MA appliance standards \(003\)](#)

**4:** [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
 August 27, 2021

**5:** [2021 NMR C&I Omnibus NTG](#)

### 3.18. Food Service - Electric Griddle

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CEG                                      |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® griddle. ENERGY STAR® griddles save energy cooking and idle times due to improved cooking efficiency and idle energy rates.

#### BCR Measure IDs:

| Measure Name                              | Core Initiative                            | BCR Measure ID |
|-------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Commercial Electric Griddle | C&I New & Replacement Equipment (CI_EQUIP) | EC2b032        |
| Midstream - Commercial Electric Griddle   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b068        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Savings Calculator<sup>1</sup>

| Measure Name                | kWh   | kW   |
|-----------------------------|-------|------|
| Commercial Electric Griddle | 3,965 | 0.90 |

$$\text{delkWh} = \text{SAVE} \times \text{Width} \times \text{Hours}$$

$$\text{delkW} = \text{SAVE} \times \text{Width}$$

Where:

$\Delta\text{kWh}$  = gross annual kWh savings from the measure. With default Width, average savings are 3,965 kWh.

$\Delta\text{kW}$  = gross average kW savings from the measure. With default Width, average savings are 0.90 kW.

SAVE = Savings per foot of griddle width: 0.15 kW/ft

Width = Width of griddle in feet. Default of 3 feet.

Hours = Griddles are assumed to operate 313 days per year. The average griddle is assumed to operate 12 hours per day, or 3,756 hours per year.

#### Baseline Efficiency:

The baseline efficiency case is a typically sized, 6 sq. ft. commercial griddle with a cooking energy efficiency of 65%, production capacity of 35 pounds per hour, and idle energy rate of 400 W/sq. ft.



**High Efficiency:**

The high efficiency case is a typically sized, 6 sq. ft. commercial griddle with a cooking energy efficiency of 70%, production capacity of 40 pounds per hour, and idle energy rate of 320 W/sq. ft.

**Measure Life:**

The measure life for a new griddle is 12 years.<sup>2</sup>

| Measure Name                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------|-----------------|-----|-----|-----|-----|-----|
| Commercial Electric Griddle | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Electric Griddle | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

Net-to-gross factors are based on study results.<sup>3</sup>

| Measure          | Core Initiative | PA  | FR    | SO <sub>p</sub> | SO <sub>NP</sub> | NTG   |
|------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Electric Griddle | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results.

| Measure Name     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Electric Griddle | CI_EQUIP        | CLC | \$0.00             | \$0.00               | \$0.007           | \$0.00              | \$0.00              | \$0.00                |

**Endnotes:**

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**1:**

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_serviceAugust 27, 2021 ENERGY STAR Calculator - New Baselines and Efficiencies 082721](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_serviceAugust27,2021/ENERGY_STAR_Calculator_-_New_Baselines_and_Efficiencies_082721)

**2:**

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_serviceAugust 27, 2021 ENERGY STAR Calculator - New Baselines and Efficiencies 082721](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_serviceAugust27,2021/ENERGY_STAR_Calculator_-_New_Baselines_and_Efficiencies_082721)

**3:** NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.19. Food Service - Electric Oven

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CEO                                      |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® commercial convection oven or commercial combination oven. ENERGY STAR® commercial ovens save energy during preheat, cooking and idle times due to improved cooking efficiency, and preheat and idle energy rates.

Combination ovens can be used either as convection ovens or as steamers.

#### BCR Measure IDs:

| Measure Name                                                  | Core Initiative                            | BCR Measure ID |
|---------------------------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Commercial Electric Ovens, Full Size Convection | C&I New & Replacement Equipment (CI_EQUIP) | EC2b029        |
| Foodservice - Commercial Electric Ovens, Combination Oven     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b030        |
| Midstream - Commercial Electric Ovens, Full Size Convection   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b065        |
| Midstream - Commercial Electric Ovens, Combination Oven       | C&I New & Replacement Equipment (CI_EQUIP) | EC2b066        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Commercial Food Service Savings Calculator:

$$\Delta kWh = kWh$$

$$\Delta kW = kWh / \text{hours}$$

Where:

$\Delta kWh$  = gross annual kWh savings from the measure. See table below.

$\Delta kW$  = gross average kW savings from the measure. See table below.

Hours = Annual hours of operation. See Hours section below.

**Energy Savings for Commercial Ovens<sup>1</sup>**

| Equipment Type                   | ΔkW  | ΔkWh   |
|----------------------------------|------|--------|
| Full Size Convection Oven Tier 1 | 0.23 | 1,025  |
| Full Size Convection Oven Tier 2 | 0.5  | 2,465  |
| Combination Oven Tier 1          | 2.66 | 11,661 |
| Combination Oven Tier 2          | 2.96 | 12,943 |

**Baseline Efficiency:**

The baseline efficiency case for a combination oven are Steam Mode: ≥ 45% cooking efficiency, ≤ 8.0 idle rate Convection: ≤ 74% cooking efficiency, ≤ 1.31 kW idle rate.<sup>2 3</sup>

The baseline efficiency case is a convection oven with a cooking energy efficiency of 68% and idle energy rate of 1.8 kW.<sup>4 5</sup>

The baseline efficiencies represents the mid-point between the new Massachusetts Appliance Standard<sup>6</sup> minimum threshold (50%) and the current year baseline efficiency (35%).

**High Efficiency:**

Qualifying models must be listed in the California Energy Commission database. Electric ovens must meet ENERGY STAR specifications and have a tested heavy load potato cooking energy efficiency of 71% or more, utilizing ASTM (Standard F1496. Full-size ≤ 5 pans) electric ovens must have an idle rate of 1.6 kW or less and large full-size (>5 pans) 1.9 kW or less. Large full size electric ovens must also have a tested cooking energy efficiency of 73% or more.

**Measure Life:**

The measure life for a new commercial electric oven is 12 years.<sup>7</sup>

**Other Resource Impacts:**

There are no additional resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure        | Core Initiative    | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------|--------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Electric Ovens | CI_NB&MR, CI_EQUIP | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**Impact Factors for Calculating Net Savings:**

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Net-to-gross factors are based on study results.<sup>8</sup>

| Measure                                                         | Initiative | PA  | FR    | SO   | NPSO | NTG   |
|-----------------------------------------------------------------|------------|-----|-------|------|------|-------|
| Food Services - Commercial Electric Ovens, Full Size Convection | CI_EQUIP   | All | 25.0% | 0.2% | 8.5% | 83.7% |
| Food Services - Commercial Electric Ovens, Combination Oven     | CI_EQUIP   | All | 25.0% | 0.2% | 8.5% | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results<sup>9</sup>

| Measure Name                                                    | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Food Services - Commercial Electric Ovens, Full Size Convection | All | \$0.00             | \$0.00               | \$0.00            | \$0.007             | 0.00                | 0.00                  |
| Food Services - Commercial Electric Ovens, Combination Oven     | All | \$0.00             | \$0.00               | \$0.00            | \$0.007             | 0.00                | 0.00                  |

**Endnotes:**

- 1: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
August 27, 2021
- 2: Average between 2021 baseline and 2022 FS appliance standard baseline
- 3: Energy Star Calculator with modified baseline and measure efficiencies.  
[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service);  
August 27, 2021
- 4 : Average between 2021 baseline and 2022 FS appliance standard baseline
- 5 : Energy Star Calculator with modified baseline and measure efficiencies.  
[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service);  
August 27, 2021
- 6 : Appliance Standard.pdf
- 7 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
August 27,2021
- 8 : [2021 NMR C&I Omnibus NTG](#)
- 9 : MA20X10-B-CIOMNEI

### 3.20. Food Service - Electric Steam Cooker

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CESC                                     |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® commercial steam cooker. ENERGY STAR® steam cookers save energy during cooling and idle times due to improved cooking efficiency and idle energy rates.

#### BCR Measure IDs:

| Measure Name                                   | Core Initiative                            | BCR Measure ID |
|------------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Commercial Electric Steam Cooker | C&I New & Replacement Equipment (CI_EQUIP) | EC2b031        |
| Midstream - Commercial Electric Steam Cooker   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b067        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Commercial Food Service Calculator:<sup>1</sup>

| Measure             | kWH   | kW   |
|---------------------|-------|------|
| Steam Cooker Tier 1 | 3,947 | 0.90 |
| Steam Cooker Tier 2 | 5,306 | 1.21 |

#### Baseline Efficiency:

The Baseline Efficiency case is an electric steam cooker with a cooking efficiency of  $\geq 68\%$  and idle energy rate of  $\leq 0.4$  kW. The baseline efficiencies represent the mid-point between the new Massachusetts Appliance Standard minimum threshold (50%) and the current year baseline efficiency (35%). MA STATE Appliance Standards signed 3/26/21 starting on page 27 references what the product must meet.<sup>2 3</sup>

#### High Efficiency:

The High Efficiency case is an ENERGY STAR® electric steam cooker models must have cooking efficiency of  $\geq 38\%$  and  $\leq 0.88$  kW idle rate.

**Measure Life:**

The measure life for a new steamer is 12 years.<sup>4</sup>

**Other Resource Impacts:**

There are no additional resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Electric Steam Cooker | CI_EQUIP        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>5</sup>

| Measure                          | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|----------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Commercial Electric Steam Cooker | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results.<sup>6</sup>

| Measure Name                     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Commercial Electric Steam Cooker | CI_EQUIP        | ALL | \$0.00             | \$0.00               | \$0.00            | \$0.007             | \$0.00              | \$0.00                |

**Endnotes:**

1 :

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_serviceAugust 27, 2021 ENERGY STAR Calculator - New Baselines and Efficiencies 082721](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_serviceAugust%2027,%202021/ENERGY_STAR_Calculator_-_New_Baselines_and_Efficiencies_082721)

**2:** Appliance standards document signed 3/26/21 starting on page 27 references what the product must meet. [MA appliance standards \(003\)](#)

**3:** Energy Star Calculator with modified baseline and measure efficiencies.

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service);

August 27, 2021

**4:** [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)

June 29, 2021

**5:** [2021 NMR C&I Omnibus NTG](#)

**6:** MA20X10-B-CIOMNEI



### 3.21. Food Service - Food Holding Cabinet

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-FHC                                      |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® hot food holding cabinet (HFHC). ENERGY STAR® hot food holding cabinets are 70 percent more energy efficient than standard models. Models that meet this requirement incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door gaskets, auto-door closures, or dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. Offering full size, 3/4 size, and 1/2 half size HFHC.

#### BCR Measure IDs:

| Measure Name                                  | Core Initiative                            | BCR Measure ID |
|-----------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Food Holding Cabinet, Full Size | C&I New & Replacement Equipment (CI_EQUIP) | EC2b084        |
| Foodservice - Food Holding Cabinet, 3/4 Size  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b085        |
| Foodservice - Food Holding Cabinet, 1/2 Size  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b086        |
| Midstream - Food Holding Cabinet, Full Size   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b084        |
| Midstream - Food Holding Cabinet, 3/4 Size    | C&I New & Replacement Equipment (CI_EQUIP) | EC2b085        |
| Midstream - Food Holding Cabinet, 1/2 Size    | C&I New & Replacement Equipment (CI_EQUIP) | EC2b086        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Commercial Food Service Savings Calculator:

$$\text{kWh} = \text{kW} \times \text{Hours}$$

$$\text{kW} = \text{kWh} / \text{Hours}$$

Where:

kWh = gross annual kWh savings from the measure: See table below.

kW = gross average kW savings from the measure: See table below.

Hours = Annual hours of operation. See Hours section below.

**Energy Savings for Commercial Hot Food Holding Cabinets<sup>1</sup>**

| Equipment Type     | kW   | kWh   |
|--------------------|------|-------|
| Full Size - Tier 1 | 0.20 | 887   |
| 3/4 Size – Tier 1  | 0.19 | 854   |
| 1/2 Size – Tier 1  | 0.11 | 493   |
| Full Size - Tier 2 | 0.33 | 1,445 |
| 3/4 Size - Tier 2  | 0.28 | 1,215 |
| 1/2 Size - Tier 2  | 0.15 | 657   |

**Baseline Efficiency:**

The baseline efficiency is the average between 2021 baseline and 2022 Food Service appliance standard baseline. The baseline efficiencies represent the mid-point between the new Massachusetts Appliance Standard minimum threshold (50%) and the current year baseline efficiency (35%)<sup>2</sup>

The baseline efficiency idle rate is as follows:

| Equipment Type     | kW idle rate |
|--------------------|--------------|
| Full Size - Tier 1 | ≤ 0.65       |
| 3/4 Size - Tier 1  | ≤ 0.51       |
| 1/2 Size - Tier 1  | ≤ 0.31       |
| Full Size - Tier 2 | ≤ 0.65       |
| 3/4 Size - Tier 2  | ≤ 0.51       |
| 1/2 Size Tier 2    | ≤ 0.31       |

**High Efficiency:**

The high efficiency idle energy rate for HFHC is as follows:

| Equipment Type     | kW idle rate |
|--------------------|--------------|
| Full Size - Tier 1 | ≤ 0.30       |
| 3/4 Size - Tier 1  | ≤ 0.29       |
| 1/2 Size - Tier 1  | ≤ 0.2        |
| Full Size - Tier 2 | ≤ 0.21       |

|                   |        |
|-------------------|--------|
| 3/4 Size - Tier 2 | ≤ 0.14 |
| 1/2 Size Tier 2   | ≤ 0.11 |

**Measure Life:**

The measure life for a new commercial HFHC is 12 years.<sup>2</sup>

| Measure Name         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------|-----------------|-----|-----|-----|-----|-----|
| Food Holding Cabinet | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure              | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Food Holding Cabinet | CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>3</sup>

| Measure                                         | Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------------------------|------------|-----|------|-----------------|------------------|-------|
| Food Services - Food Holding Cabinet, Full Size | CI_EQUIP   | All | 0.25 | 0.002           | 0.085            | 0.837 |
| Food Services - Food Holding Cabinet, 3/4 Size  | CI_EQUIP   | All | 0.25 | 0.002           | 0.085            | 0.837 |
| Food Services - Food Holding Cabinet, 1/2 Size  | CI_EQUIP   | All | 0.25 | 0.002           | 0.085            | 0.837 |

**Non-Energy Impacts:**

Non-energy impacts are based on study results. <sup>4</sup>

**Endnotes:**

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**1:**

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)

**2:** Appliance standards document signed 3/26/21 starting on page 27 references what the product must meet. [MA appliance standards \(003\)](#)

**2:** [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021

**3:** NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

**4:** MA20X10-B-CIOMNEI

### 3.22. Food Service - Gas Fryer

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CF                                       |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

The installation of a natural-gas fired fryer that is either ENERGY STAR® rated or has a heavy-load cooking efficiency of at least 50%. Qualified fryers use advanced burner and heat exchanger designs to use fuel more efficiently, as well as increased insulation to reduce standby heat loss.

#### BCR Measure IDs:

| Measure Name                         | Core Initiative                            | BCR Measure ID |
|--------------------------------------|--------------------------------------------|----------------|
| Foodservice - Fryer, Gas - Midstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b040        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the ENERGY STAR Commercial Food Service (CFS) Product Calculator.<sup>1</sup>

| Measure Name                      | MMBTU |
|-----------------------------------|-------|
| Food Services, Fryer, Gas, Tier 1 | 19.7  |
| Food Services, Fryer, Gas, Tier 2 | 33.0  |

#### Baseline Efficiency:

The baseline efficiency case is a non-Energy Star qualified fryer with a baseline cooking efficiency of 42.5%. This baseline efficiency represents the mid-point between the new Massachusetts Appliance Standard minimum threshold (50%) and the current year baseline efficiency (35%).

#### High Efficiency:

The Tier 1 high efficiency case is an Energy Star qualified fryer with a baseline cooking efficiency of 50%. The Tier 2 high efficiency case is an Energy Star qualified fryer with a baseline cooking efficiency of 56%.

**Measure Life:**

The measure life is 12 years.<sup>2</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Commercial Fryer | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name     | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Commercial Fryer | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>3</sup>

| Measure          | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|------|-----------------|------------------|------|
| Commercial Fryer | CI_EQUIP        | All | 0.37 | 0.02            | 0.19             | 0.84 |

**Non-Energy Impacts:**

NEI values can be found in Appendix B.<sup>4</sup>

| Measure Name     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Commercial Fryer | CI_EQUIP        | All |                    |                      |                   |                     | \$5.10              |                       |

**Endnotes:**

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- 1: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 2: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 3: NMR Group, Inc. (2021) Prescriptive and Custom Net-to-Gross Omnibus Study  
[2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)
- 4: O&M and Non-O&M NEI Study.

### 3.23. Food Service - Gas Griddle

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CG                                       |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a single-sided high efficiency gas griddle that meets ENERGY STAR® specifications or have a tested heavy load cooking efficiency of at least 38% and an idle energy rate  $\leq$  2,650 Btu/h per square foot of cooking surface utilizing ASTM Standard F1275.

#### BCR Measure IDs:

| Measure Name                          | Core Initiative                            | BCR Measure ID |
|---------------------------------------|--------------------------------------------|----------------|
| Foodservice, Griddle, Gas - Midstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b039        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the ENERGY STAR Commercial Food Service (CFS) Product Calculator.<sup>1</sup>

| Measures     | MMBTu |
|--------------|-------|
| Griddle, Gas | 15.3  |

#### Baseline Efficiency:

The baseline efficiency case is a non-ENERGY STAR® qualified gas griddle. ENERGY STAR® defines the baseline case as a unit with a tested heavy load cooking efficiency of 32% and an idle energy rate of 3,500 Btu/h per square foot of cooking surface utilizing ASTM Standard F1275.

#### High Efficiency:

The high efficiency case is an ENERGY STAR® qualified gas griddle with a tested heavy load cooking efficiency of at least 38% and an idle energy rate  $\leq$  2,650 Btu/h per square foot of cooking surface utilizing ASTM Standard F1275.

#### Measure Life:

The measure life is 12 years.<sup>2</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Griddle, Gas | CI_EQUIP        | All | 12  | n/a | n/a | 12  |



### 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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Griddle, Gas | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for the gas measure since there are no electric savings claimed.

### Coincidence Factors:

Not applicable for gas measure since no electric savings are claimed.

### Impact Factors for Calculating Net Savings:

All PAs use Statewide prescriptive net-to-gross results.<sup>3</sup>

| Measure      | Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>np</sub> | NTG  |
|--------------|------------|-----|------|-----------------|------------------|------|
| Griddle, Gas | CI_EQUIP   | All | 0.37 | 0.02            | 0.19             | 0.84 |

### Non-Energy Impacts:

NEI Values can be found in Appendix B.<sup>4</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Griddle, Gas | CI_NB&MR        | All |                    |                      |                   |                     | \$5.10              |                       |

### Endnotes:

- 1: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 2: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 3: NMR Group, Inc. (2021) Prescriptive and Custom Net-to-Gross Omnibus Study.  
[2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)
- 4: O&M and Non-O&M NEI Study.

### 3.24. Food Service - Gas Oven

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FS-CO                                        |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of High Efficiency Gas Ovens.

#### BCR Measure IDs:

| Measure Name                                          | Core Initiative                            | BCR Measure ID |
|-------------------------------------------------------|--------------------------------------------|----------------|
| Foodservice, Ovens, Combination Oven, Gas - Midstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b035        |
| Foodservice, Ovens, Convection Oven, Gas - Midstream  | C&I New & Replacement Equipment (CI_EQUIP) | GC2b036        |
| Foodservice, Ovens, Conveyer Oven, Gas - Midstream    | C&I New & Replacement Equipment (CI_EQUIP) | GC2b037        |
| Foodservice, Ovens, Rack Oven, Gas - Midstream        | C&I New & Replacement Equipment (CI_EQUIP) | GC2b038        |

#### Algorithms for Calculating Primary Energy Impact:

Rack Oven, Convection Oven and Combination Oven unit savings are deemed based on the ENERGY STAR Commercial Food Services (CFS) Product Calculator using the specified baseline and high efficiency inputs as listed below.<sup>1</sup>

Savings for the Conveyor Oven are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator:<sup>2</sup>

| Measure Name             | ΔMMBtu |
|--------------------------|--------|
| Convection Oven, Tier 1  | 15.6   |
| Convection Oven, Tier 2  | 33.8   |
| Combination Oven, Tier 1 | 14.8   |
| Combination Oven, Tier 2 | 21.7   |
| Conveyer Oven            | 88.4   |
| Rack Oven                | 252.6  |

### Baseline Efficiency:

The baseline efficiencies for the Commercial Ovens are outlined in the table below.

The baseline efficiency for the Convection Oven is an average between the current program baseline (30%) and the Massachusetts Appliance Standards baseline efficiency (46%). The Massachusetts Appliance Standards baseline efficiency is based on the ENERGY STAR® V2.2 Commercial Ovens specification.

The baseline efficiency for the Combination Oven is an average between the current program baseline (35%) and the Massachusetts Appliance Standards baseline efficiency (41%). The Massachusetts Appliance Standards baseline efficiency is based on the ENERGY STAR® V2.2 Commercial Ovens specification.

These performance parameters are drawn from a sample of economy grade equipment tested by the Food Service Technology Center based on ASTM F1496 (Convection Oven), ASTM F2861 (Combination Oven), and ASTM 2093 (Conveyor Oven and Rack Oven).

| Measure Name     | Baseline Efficiency                                                                                                            |
|------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Convection Oven  | 38% Cooking Efficiency; 15,000 Btu/hr idle rate                                                                                |
| Combination Oven | Steam Mode: 38% Cooking Efficiency; 15,256 Btu/hr idle rate<br>Convection Mode: 54% Cooking Efficiency; 9,607 Btu/hr idle rate |
| Conveyor Oven    | 20% Cooking Efficiency; 70,000 Btu/hr idle rate                                                                                |
| Rack Oven        | 30% Baking Efficiency; 65,000 Btu/hr idle rate                                                                                 |

### High Efficiency:

High efficiency case is an oven that meets or exceeds the high efficiency ratings per oven type shown in table below.

| Measure Name             | Efficiency Requirement                                                                                                                     |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Convection Oven, Tier 1  | >= 46% Cooking Efficiency; <= 12,000 Btu/hr idle rate                                                                                      |
| Convection Oven, Tier 2  | >= 51% Cooking Efficiency; <= 7,400 Btu/hr idle rate                                                                                       |
| Combination Oven, Tier 1 | Steam Mode: >= 48% Cooking Efficiency; <= 10,511 Btu/hr idle rate<br>Convection Mode: >= 58% Cooking Efficiency; <= 8,425 Btu/hr idle rate |
| Combination Oven, Tier 2 | Steam Mode: >= 48% Cooking Efficiency; <= 8,700 Btu/hr idle rate<br>Convection Mode: >= 58% Cooking Efficiency; <= 6,800 Btu/hr idle rate  |

|               |                                                      |
|---------------|------------------------------------------------------|
| Conveyer Oven | >= 42% Cooking Efficiency;<=57,000 Btu/hr idle rate  |
| Rack Oven     | >= 52% Baking Efficiency; <= 30,000 Btu/hr idle rate |

**Measure Life:**

The measure life is 12 years for all commercial ovens.<sup>3 4</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Oven         | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Convection Oven  | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Combination Oven | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Conveyer Oven    | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Rack Oven        | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net-to-gross factors are based on study results.<sup>5</sup>

| Measure               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------|-----------------|-----|------|-----------------|------------------|------|
| Combination Oven, Gas | CI_EQUIP        | All | 0.37 | 0.02            | 0.19             | 0.84 |
| Convection Oven, Gas  | CI_EQUIP        | All | 0.37 | 0.02            | 0.19             | 0.84 |

|                    |          |     |      |      |      |      |
|--------------------|----------|-----|------|------|------|------|
| Conveyor Oven, Gas | CI_EQUIP | All | 0.37 | 0.02 | 0.19 | 0.84 |
| Rack Oven, Gas     | CI_EQUIP | All | 0.37 | 0.02 | 0.19 | 0.84 |

**Non-Energy Impacts:**

NEI values can be found in Appendix B. <sup>6</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Oven         | CI_EQUIP        | All |                    |                      |                   |                     | \$5.10              |                       |

**Endnotes:**

- 1: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 2: <https://caenergywise.com/calculators/> and <http://www.deeresources.net/workpapers>
- 3: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 4: <https://caenergywise.com/calculators/> and <http://www.deeresources.net/workpapers>
- 5: NMR Group, Inc. (2021) Prescriptive and Custom Net-to-Gross Omnibus Study  
[2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)
- 6: O&M and Non-O&M NEI Study.

### 3.25. Food Service - Gas Steamer

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CS                                       |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

The installation of an ENERGY STAR® rated natural-gas fired steamer, either connectionless or steam-generator design, with heavy-load cooking efficiency of at least 38%. Qualified steamers reduce heat loss due to better insulation, improved heat exchange, and more efficient steam delivery systems.

#### BCR Measure IDs:

| Measure Name                               | Core Initiative                            | BCR Measure ID |
|--------------------------------------------|--------------------------------------------|----------------|
| Foodservice, Steam Cooker, Gas - Midstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b041        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the ENERGY STAR Commercial Food Service (CFS) Product Calculator.<sup>1</sup>

| Measure                                 | MMBTu |
|-----------------------------------------|-------|
| Food Service, Steam Cooker, Gas, Tier 1 | 32.0  |
| Food Service, Steam Cooker, Gas, Tier 2 | 46.8  |

#### Baseline Efficiency:

The baseline efficiency case is a steamer with a 26.5% cooking efficiency and an idle rate of 13,750 Btu/hr. This baseline efficiency represents the mid-point between the new Massachusetts Appliance Standard minimum threshold (38%), based on the ENERGY STAR® V1.2 product specification for commercial steam cookers, and the current year baseline efficiency (15%).

#### High Efficiency:

The Tier 1 high efficiency case is an ENERGY STAR® rated natural-gas fired steamer, with a tested heavy-load cooking efficiency of at least 45% utilizing ASTM F1484 and an idle rate of less than or equal to 12,500 Btu/hr. The Tier 2 high efficiency case is an ENERGY STAR® rated natural-gas fired steamer, with a tested heavy-load cooking efficiency of at least 45% utilizing ASTM F1484 and an idle rate of less than or equal to 7,100 Btu/hr.

**Measure Life:**

The measure life is 12 years.<sup>2</sup>

| Measure Name      | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------|-----------------|-----|-----|-----|-----|-----|
| Steam Cooker, Gas | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts associated with this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Steam Cooker, Gas | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | 1.00             | 1.00             | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>3</sup>

| Measure           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------|-----------------|-----|------|-----------------|------------------|------|
| Steam Cooker, Gas | CI_EQUIP        | All | 0.37 | 0.02            | 0.19             | 0.84 |

**Non-Energy Impacts:**

NEI values can be found in Appendix B.<sup>4</sup>

| Measure Name      | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Steam Cooker, Gas | CI_NB&MR        | All |                    |                      |                   |                     | \$5.10              |                       |

**Endnotes:**

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- 1: [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)
- 2: <https://caenergywise.com/calculators/> and <http://www.deeresources.net/workpapers>
- 3: NMR Group, Inc. (2021) Prescriptive and Custom Net-to-Gross Omnibus Study  
[2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)
- 4: O&M and Non-O&M NEI Study.



### 3.26. Food Service - Gas Underfired Broiler

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FS-UFB                                       |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

The installation of a high efficiency natural-gas underfired broiler.

#### BCR Measure IDs:

| Measure Name                                            | Core Initiative                            | BCR Measure ID |
|---------------------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Commercial Underfired Broiler - Midstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b056        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated as the difference between the baseline and efficient measures. Savings are deemed based on the following algorithm from the California eTRM entry for Underfired Broilers. <sup>1</sup>  
 Savings = Energy Consumption<sub>Base</sub> - Energy Consumption<sub>Eff</sub>

#### Where:

$$\text{Energy Consumption}_{\text{Base}} = [\text{IER}_{\text{Base}} \times \text{OHD}_{\text{Base}} \times \text{OHY}_{\text{Base}}] / 100,000$$

$$\text{Energy Consumption}_{\text{Eff}} = [\text{IER}_{\text{Eff}} \times \text{OHD}_{\text{Eff}} \times \text{OHY}_{\text{Eff}}] / 100,000$$

IER<sub>Base</sub> = 25,000 (Btuh) (Broiler Idle Energy Rate)

IER<sub>Eff</sub> = 20,000 (Btuh) (Broiler Idle Energy Rate)

OHD<sub>Base</sub> = 12 (Operating Hours/Day in the Baseline Case)

OHD<sub>Eff</sub> = 12 (Operating Hours/Day in the Efficient Case)

OHY<sub>Base</sub> = 363 (Operating Hours/Year in the Baseline Case)

OHY<sub>Eff</sub> = 363 (Operating Hours/Year in the Efficient Case)

100,000 = Btu/Therm

| Measure Name       | MMBTU |
|--------------------|-------|
| Underfired Broiler | 21.8  |

#### Baseline Efficiency:

The baseline efficiency case is a unit with an input rate > 22 kBtu/hr/ln-ft at 600 degrees F and an idle and cooking energy rate = 25,000 Btu/hr with a production capacity of 25 lb/hr.

**High Efficiency:**

The high efficiency case is a unit with an input rate  $\leq 22$  kBtu/hr/ln-ft at 600 degrees F and an idle and cooking energy rate  $\leq 20,000$  Btu/hr with a production capacity of 20 lb/hr.

**Measure Life:**

The measure life is 12 years.<sup>2</sup>

| Measure Name       | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------|-----------------|-----|-----|-----|-----|-----|
| Underfired Broiler | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Underfired Broiler | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>3</sup>

| Measure            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------|-----------------|-----|------|-----------------|------------------|------|
| Underfired Broiler | CI_EQUIP        | All | 0.37 | 0.02            | 0.19             | 0.84 |

**Non-Energy Impacts:**

NEI values can be found in Appendix B.<sup>4</sup>

| Measure Name       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Underfired Broiler | CI_EQUIP        | All |                    |                      |                   |                     | \$5.10              |                       |

**Endnotes:**

- 1: California Technical Reference Manual. <https://www.caetrm.com/measure/SWFS019/02/>
- 2: California Technical Reference Manual. <https://www.caetrm.com/measure/SWFS019/02/>
- 3: NMR Group, Inc. (2021) Prescriptive and Custom Net-to-Gross Omnibus Study [2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)
- 4: O&M and Non-O&M NEI Study.

### 3.27. Food Service - High Temperature Commercial Dishwasher

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-HTCD                                     |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® high temperature commercial dishwasher in a building with gas domestic hot water. High temperature dishwashers use a booster heater to raise the rinse water temperature to 180 F – hot enough to sterilize dishes and assist in drying. Electric savings are achieved through savings to the electric booster.

#### BCR Measure IDs:

| Measure Name                                            | Core Initiative                            | BCR Measure ID |
|---------------------------------------------------------|--------------------------------------------|----------------|
| Foodservice- High Temp Under Counter Dishwasher         | C&I New & Replacement Equipment (CI_EQUIP) | EC2b037        |
| Foodservice - High Temp Door Type Dishwasher            | C&I New & Replacement Equipment (CI_EQUIP) | EC2b038        |
| Foodservice - High Temp Single Tank Conveyer Dishwasher | C&I New & Replacement Equipment (CI_EQUIP) | EC2b039        |
| Foodservice - High Temp Multi Tank Conveyer Dishwasher  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b040        |
| Foodservice - High Temp Pots & Pans Dishwasher          | C&I New & Replacement Equipment (CI_EQUIP) | EC2b041        |
| Midstream - High Temp Under Counter Dishwasher          | C&I New & Replacement Equipment (CI_EQUIP) | EC2b073        |
| Midstream - High Temp Door Type Dishwasher              | C&I New & Replacement Equipment (CI_EQUIP) | EC2b074        |
| Midstream - High Temp Single Tank Conveyer Dishwasher   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b075        |
| Midstream - High Temp Multi Tank Conveyer Dishwasher    | C&I New & Replacement Equipment (CI_EQUIP) | EC2b076        |
| Midstream - High Temp Pots & Pans Dishwasher            | C&I New & Replacement Equipment (CI_EQUIP) | EC2b077        |

## Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Equipment Savings Calculator:

$$\text{kWh} = \text{kW} \times \text{hours}$$

$$\text{kW} = \text{kWh} / \text{hours}$$

Where:

kWh = gross annual kWh savings from the measure. See table below.

kW = gross average kW savings from the measure. See table below.

Hours = Average annual equipment operating hours. See Hours section below.

Energy Savings for High Temperature Commercial Dishwashers:<sup>1</sup>

| Equipment Type                | kW   | kWh    |
|-------------------------------|------|--------|
| Under Counter - Tier 1        | 0.36 | 1,585  |
| Door Type - Tier 1            | 1.35 | 5,932  |
| Single Tank Conveyor - Tier 1 | 1.05 | 4,606  |
| Multi Tank Conveyor - Tier 1  | 3.13 | 13,704 |
| Pot, Pan and Utensil - Tier 1 | 0.38 | 1,655  |
| Under Counter - Tier 2        | 0.62 | 2,717  |
| Door Type - Tier 2            | 1.52 | 6,662  |
| Single Tank Conveyor - Tier 2 | 1.45 | 6,358  |
| Multi Tank Conveyor - Tier 2  | 3.66 | 16,040 |
| Pot, Pan and Utensil - Tier 2 | 0.48 | 2,093  |

## Baseline Efficiency:

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows<sup>2</sup>:

| Dishwasher Type       | Gallons per Rack | Idle Energy Rate (kW) Tier 1 | Idle Energy Rate (kW) Tier 2 |
|-----------------------|------------------|------------------------------|------------------------------|
| Under Counter         | ≤ 0.98           | ≤ 0.63                       | ≤ 0.63                       |
| Door Type             | ≤ 1.09           | ≤ 0.79                       | ≤ 0.79                       |
| Single Tank Conveyor  | ≤ 0.79           | ≤ 1.72                       | ≤ 1.72                       |
| Multi Tank Conveyor   | ≤ 0.76           | ≤ 2.42                       | ≤ 2.42                       |
| Pot, Pan, and Utensil | ≤ 0.64           | ≤ 1.2                        | ≤ 1.2                        |

The baseline efficiencies represent the mid-point between the new Massachusetts Appliance Standard minimum threshold (50%) and the current year baseline efficiency (35%)<sup>3</sup>.

### High Efficiency:

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR® Efficiency Requirements as follows<sup>4</sup>:

| Dishwasher Type       | Gallons per Rack | Idle Energy Rate (kW) Tier 1 | Idle Energy Rate (kW) Tier 2 |
|-----------------------|------------------|------------------------------|------------------------------|
| Under Counter         | ≤ 0.86           | ≤ 0.50                       | ≤ 0.30                       |
| Door Type             | ≤ 0.89           | ≤ 0.70                       | ≤ 0.55                       |
| Single Tank Conveyor  | ≤ 0.70           | ≤ 1.50                       | ≤ 1.20                       |
| Multi Tank Conveyor   | ≤ 0.54           | ≤ 2.25                       | ≤ 1.85                       |
| Pot, Pan, and Utensil | ≤ 0.58           | ≤ 1.2                        | ≤ 0.90                       |

### Measure Life:

The measure life for a new high temperature dishwasher is given by type below:<sup>5</sup>

| Dishwasher Type               | Life (years) |
|-------------------------------|--------------|
| Under Counter                 | 10           |
| Door Type                     | 15           |
| Single or Multi Tank Conveyor | 20           |
| Pot, Pan, and Utensil         | 10           |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure                     | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| High Temperature Dishwasher | CI_EQUIP        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to gross results<sup>5</sup>

| Measure                              | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Food Services - High Temp Dishwasher | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results<sup>6</sup>.

| Measure                              | Core Initiative | Annual \$ per unit | One time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One time \$ per Therm |
|--------------------------------------|-----------------|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Food Services - High Temp Dishwasher | CI_EQUIP        | \$0.00             | \$0.00               | \$0.00            | \$0.007             | \$0.00              | \$0.00                |

**Endnotes:**

- 1 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)
- 2 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)
- 3 : Appliance standards document signed 3/26/21 starting on page 27 references what the product must meet. [MA appliance standards \(003\)](#)
- 4 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)
- 5 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021
- 5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)
- 6 : MA20X10-B-CIOMNEI

### 3.28. Food Service - Ice Machine

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-CIM                                      |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® commercial ice machine. Commercial ice machines meeting the ENERGY STAR® specifications are on average 15 percent more energy efficient and 10 percent more water-efficient than standard models. ENERGY STAR® qualified equipment includes ice-making head (IMH), self-contained (SCU), and remote condensing units (RCU).

#### BCR Measure IDs:

| Measure Name                                                              | Core Initiative                            | BCR Measure ID |
|---------------------------------------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Commercial Ice Machine, Ice Making Head                     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b078        |
| Foodservice - Commercial Ice Machine, Self Contained Unit                 | C&I New & Replacement Equipment (CI_EQUIP) | EC2b079        |
| Foodservice - Commercial Ice Machine, Remote Condensing Unit (Batch)      | C&I New & Replacement Equipment (CI_EQUIP) | EC2b080        |
| Foodservice - Commercial Ice Machine, Remote Condensing Unit (Continuous) | C&I New & Replacement Equipment (CI_EQUIP) | EC2b081        |
| Midstream - Commercial Ice Machine, Ice Making Head                       | C&I New & Replacement Equipment (CI_EQUIP) | EC2b042        |
| Midstream - Commercial Ice Machine, Self Contained Unit                   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b043        |
| Midstream - Commercial Ice Machine, Remote Condensing Unit (Batch)        | C&I New & Replacement Equipment (CI_EQUIP) | EC2b044        |
| Midstream - Commercial Ice Machine, Remote Condensing Unit (Continuous)   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b045        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Commercial Food Service Calculator.

$$\text{kWh} = \text{kWh}$$

$$\text{kW} = \text{kWh} / \text{hours}$$



Where:

kWh = gross annual kWh savings from the measure. See table below.

kW = gross average kW savings from the measure. See table below.

Hours = Average annual equipment operating hours, see Hours section below.

Energy Savings for Commercial Ice Machine:<sup>1</sup>

| Equipment Type                      | kW   | kWh  |
|-------------------------------------|------|------|
| Ice Making Head                     | 0.30 | 1574 |
| Self Contained Unit                 | 0.30 | 680  |
| Remote Condensing Unit (Batch)      | 0.30 | 1322 |
| Remote Condensing Unit (Continuous) | 0.30 | 3235 |

### Baseline Efficiency:

The baseline efficiency case is a Federal Standard Compliant baseline consistent with current federal standards effective 1/28/2018. <https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-H/subject-group-ECFR055e135ff65e6f5/section-431.136>

### High Efficiency:

The high efficiency case is a commercial ice machine meeting the ENERGY STAR® Specifications V3.0 Efficiency Requirements.<sup>2</sup>

### Measure Life:

The measure life for a new ice making machine is assumed to be 8 years.<sup>3</sup>

| Measure Name       | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------|-----------------|-----|-----|-----|-----|-----|
| Ice Making Machine | CI_EQUIP        | All | 10  | n/a | n/a | 10  |

### Other Resource Impacts:

There are water savings associated with this measure.<sup>4</sup>

| Dishwasher Type                     | Annual water savings (gal/unit) |
|-------------------------------------|---------------------------------|
| Ice Making Head                     | 6,228                           |
| Self Contained Unit                 | 4,933                           |
| Remote Condensing Unit (Batch)      | 6,611                           |
| Remote Condensing Unit (Continuous) | 0                               |

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Ice Making Machine | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide prescriptive net-to-gross results.<sup>5</sup>

| Measure            | Core Initiative | PA  | FR    | SO <sub>p</sub> | SO <sub>NP</sub> | NTG   |
|--------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Ice Making Machine | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results<sup>6</sup>.

| Measure            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Ice Making Machine | CI_EQUIP        | ALL | \$0.00             | \$0.00               | \$0.00            | \$0.007             | \$0.00              | \$0.00                |

**Endnotes:**

1 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)

2 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
June 29, 2021

3 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
August 27, 2021

4 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)

5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

6 : MA20X10-B-CIOMNEI

### 3.29. Food Service - Low Temperature Commercial Dishwasher

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-LTCD                                     |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® low temperature commercial dishwasher in a facility with electric hot water heating. Low temperature dishwashers use the hot water supplied by the kitchen’s existing water heater and use a chemical sanitizing agent in the final rinse cycle and sometimes a drying agent.

#### BCR Measure IDs:

| Measure Name                                           | Core Initiative                            | BCR Measure ID |
|--------------------------------------------------------|--------------------------------------------|----------------|
| Foodservice - Low Temp Under Counter Dishwasher        | C&I New & Replacement Equipment (CI_EQUIP) | EC2b033        |
| Foodservice - Low Temp Door Type Dishwasher            | C&I New & Replacement Equipment (CI_EQUIP) | EC2b034        |
| Foodservice - Low Temp Single Tank Conveyer Dishwasher | C&I New & Replacement Equipment (CI_EQUIP) | EC2b035        |
| Foodservice - Low Temp Multi Tank Conveyer Dishwasher  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b036        |
| Midstream - Low Temp Under Counter Dishwasher          | C&I New & Replacement Equipment (CI_EQUIP) | EC2b069        |
| Midstream - Low Temp Door Type Dishwasher              | C&I New & Replacement Equipment (CI_EQUIP) | EC2b070        |
| Midstream - Low Temp Single Tank Conveyer Dishwasher   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b071        |
| Midstream - Low Temp Multi Tank Conveyer Dishwasher    | C&I New & Replacement Equipment (CI_EQUIP) | EC2b072        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the Energy Star Commercial Food Service Savings Calculator:<sup>1</sup>

kWh = kWh  
 kW = kWh / hours

Where:

kWh = gross annual kWh savings from the measure. See table below.

kW = gross average kW savings from the measure. See table below.

Hours = Average annual equipment operating hours, see Hours section below.

**Energy Savings for Low Temperature Commercial Dishwashers:**

| Equipment Type                | kW   | kWh    |
|-------------------------------|------|--------|
| Under Counter - Tier 1        | 0.29 | 1,270  |
| Door Type - Tier 1            | 1.84 | 8,076  |
| Single Tank Conveyor - Tier 1 | 1.56 | 6,813  |
| Multi Tank Conveyor - Tier 1  | 2.15 | 9,406  |
| Under Counter - Tier 2        | 0.61 | 2,684  |
| Door Type - Tier 2            | 2.12 | 9,281  |
| Single Tank Conveyor - Tier 2 | 2.44 | 10,668 |
| Multi Tank Conveyor - Tier 2  | 3.40 | 14,881 |

**Baseline Efficiency:**

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

| Dishwasher Type      | Gallons per Rack Tier 1 | Gallons per Rack Tier 2 | Idle Energy Rate (kW) Tier 1 and 2 |
|----------------------|-------------------------|-------------------------|------------------------------------|
| Under Counter        | ≤ 1.46                  | ≤ 1.46                  | ≤ 0.50                             |
| Door Type            | ≤ 1.64                  | ≤ 1.64                  | ≤ 0.60                             |
| Single Tank Conveyor | ≤ 1.05                  | ≤ 1.05                  | ≤ 1.55                             |
| Multi Tank Conveyor  | ≤ 0.79                  | ≤ 0.79                  | ≤ 2.00                             |

The baseline is an average between 2021 baseline and 2022 food service appliance standard baseline.

The baseline efficiencies represent the mid-point between the new Massachusetts Appliance Standard<sup>2</sup> minimum threshold (50%) and the current year baseline efficiency (35%).<sup>2</sup>

**High Efficiency:**

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR efficiency requirements as follows<sup>3</sup> :

| Dishwasher Type      | Gallons per Rack Tier 1 | Gallons per Rack Tier 2 | Max Idle Energy Rate (kW) Tier 1 | Max Idle Energy Rate (kW) Tier 2 |
|----------------------|-------------------------|-------------------------|----------------------------------|----------------------------------|
| Under Counter        | ≤ 1.19                  | ≤ 1.46                  | ≤ 0.50                           | ≤ 0.25                           |
| Door Type            | ≤ 1.18                  | ≤ 1.18                  | ≤ 0.60                           | ≤ 0.30                           |
| Single Tank Conveyor | ≤ 0.79                  | ≤ 0.79                  | ≤ 1.50                           | ≤ 0.84                           |
| Multi Tank Conveyor  | ≤ 0.54                  | ≤ 0.54                  | ≤ 2.00                           | ≤ 1.00                           |

**Measure Life:**

The measure life for a new low temperature dishwasher is given by type below:<sup>4</sup>

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| Under Counter                 | CI_EQUIP        | All | 10  | n/a | n/a | 10  |
| Door Type                     | CI_EQUIP        | All | 15  | n/a | n/a | 15  |
| Single or Multi Tank Conveyor | CI_EQUIP        | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low Temperature Dishwasher | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

## Impact Factors for Calculating Net Savings:

All PAs use Statewide prescriptive net-to-gross results<sup>5</sup>

| Measure                             | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Food Services - Low Temp Dishwasher | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |

## Non-Energy Impacts:

Non-energy impacts are based on study results<sup>6</sup>.

| Measure                             | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Food Services - Low Temp Dishwasher | CI_EQUIP        | ALL | \$0.00             | \$0.00               | \$0.00            | \$0.007             | \$0.00              | \$0.00                |

## Endnotes:

1 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)

2 : Appliance standards document signed 3/26/21 starting on page 27 references what the product must meet. [MA appliance standards \(003\)](#)

3 :

[https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)

4 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service) August 27, 2021

5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

6 : MA20X10-B-CIOMNEI

### 3.30. Food Service - Refrigerator/Freezer

|                     |                                                  |
|---------------------|--------------------------------------------------|
| <b>Measure Code</b> | COM-FSE-REFFRE                                   |
| <b>Market</b>       | Commercial                                       |
| <b>Program Type</b> | Lost Opportunity, New Construction, Time of Sale |
| <b>Category</b>     | Food Service Equipment                           |

#### Measure Description:

Installation of a qualified ENERGY STAR® refrigerator or freezer (glass or solid door).

#### BCR Measure IDs:

| Measure Name                         | Core Initiative                            | BCR Measure ID |
|--------------------------------------|--------------------------------------------|----------------|
| Midstream – Refrigerator, Glass Door | C&I New & Replacement Equipment (CI_EQUIP) | EC2b089        |
| Midstream – Refrigerator, Solid Door | C&I New & Replacement Equipment (CI_EQUIP) | EC2b090        |
| Midstream – Freezer, Glass Door      | C&I New & Replacement Equipment (CI_EQUIP) | EC2b091        |
| Midstream – Freezer, Solid Door      | C&I New & Replacement Equipment (CI_EQUIP) | EC2b092        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed in accordance with the following table and based on the Energy Star Commercial Kitchen Equipment Calculator <sup>1</sup>

| Description                                     | Annual Gross kWh Savings | kW Savings |
|-------------------------------------------------|--------------------------|------------|
| Refrigerator, Glass Door, <15 ft3, Electric     | 245                      | 0.03       |
| Refrigerator, Glass Door, 15-29.9 ft3, Electric | 307                      | 0.04       |
| Refrigerator, Glass Door, 30-49.9 ft3, Electric | 540                      | 0.06       |
| Refrigerator, Glass Door, ≥50 ft3, Electric     | 610                      | 0.07       |
| Refrigerator, Solid Door, <15 ft3, Electric     | 170                      | 0.02       |
| Refrigerator, Solid Door, 15-29.9 ft3, Electric | 255                      | 0.03       |

|                                                 |       |      |
|-------------------------------------------------|-------|------|
| Refrigerator, Solid Door, 30-49.9 ft3, Electric | 245   | 0.03 |
| Refrigerator, Solid Door, ≥50 ft3, Electric     | 376   | 0.04 |
| Freezer, Glass Door, <15 ft3, Electric          | 427   | 0.05 |
| Freezer, Glass Door, 15-29.9 ft3, Electric      | 681   | 0.08 |
| Freezer, Glass Door, 30-49.9 ft3, Electric      | 1,062 | 0.12 |
| Freezer, Glass Door, ≥50 ft3, Electric          | 1,486 | 0.17 |
| Freezer, Solid Door, <15 ft3, Electric          | 212   | 0.02 |
| Freezer, Solid Door, 15-29.9 ft3, Electric      | 486   | 0.06 |
| Freezer, Solid Door, 30-49.9 ft3, Electric      | 541   | 0.06 |
| Freezer, Solid Door, ≥50 ft3, Electric          | 589   | 0.07 |
| Refrigerator, Glass Door, <15 ft3, Electric     | 245   | 0.03 |
| Refrigerator, Glass Door, 15-29.9 ft3, Electric | 307   | 0.04 |
| Refrigerator, Glass Door, 30-49.9 ft3, Electric | 540   | 0.06 |
| Refrigerator, Glass Door, ≥50 ft3, Electric     | 610   | 0.07 |
| Refrigerator, Solid Door, <15 ft3, Electric     | 170   | 0.02 |
| Refrigerator, Solid Door, 15-29.9 ft3, Electric | 255   | 0.03 |
| Refrigerator, Solid Door, 30-49.9 ft3, Electric | 245   | 0.03 |
| Refrigerator, Solid Door, ≥50 ft3, Electric     | 376   | 0.04 |
| Freezer, Glass Door, <15 ft3, Electric          | 427   | 0.05 |
| Freezer, Glass Door, 15-29.9 ft3, Electric      | 681   | 0.08 |
| Freezer, Glass Door, 30-49.9 ft3, Electric      | 1,062 | 0.12 |
| Freezer, Glass Door, ≥50 ft3, Electric          | 1,486 | 0.17 |
| Freezer, Solid Door, <15 ft3, Electric          | 212   | 0.02 |
| Freezer, Solid Door, 15-29.9 ft3, Electric      | 486   | 0.06 |
| Freezer, Solid Door, 30-49.9 ft3, Electric      | 541   | 0.06 |
| Freezer, Solid Door, ≥50 ft3, Electric          | 589   | 0.07 |

**Baseline Efficiency:**



The baseline efficiency case is a refrigerator or freezer with standard energy consumption.

**High Efficiency:**

The high efficiency case is an Energy Star rated refrigerator or freezer.

**Measure Life<sup>2</sup>:**

| Measure Name                                                   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Food Services Upstream - Commercial Refrigerator/Freezer (All) | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                                                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Food Services Upstream - Commercial Refrigerator/Freezer (All) | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are the default food service factors of 0.90.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on study results.<sup>3</sup>

| Measure                                                        | Core Initiative | PA  | FR    | SO <sub>p</sub> | SO <sub>NP</sub> | NTG   |
|----------------------------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Food Services Upstream - Commercial Refrigerator/Freezer (All) | CI_EQUIP        | All | 25.0% | 0.2%            | 8.5%             | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results.<sup>4</sup>

| Measure Name                                                   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Food Services Upstream - Commercial Refrigerator/Freezer (All) | CI_EQUIP        | ALL | \$0.00             | \$0.00               | \$0.00            | \$0.007             | \$0.00              | \$0.00                |

**Endnotes:**

- 1 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
 August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)
- 2 : [https://www.energystar.gov/partner\\_resources/energy\\_star\\_training\\_center/commercial\\_food\\_service](https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_service)  
 August 27, 2021 [ENERGY STAR Calculator - New Baselines and Efficiencies 082721](#)
- 3 : [2021 NMR C&I Omnibus NTG](#)
- 4 : MA20X10-B-CIOMNEI

### 3.31. HVAC - Boiler Reset Control

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-BSC                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program

#### BCR Measure IDs:

| Measure Name                   | Core Initiative                           | BCR Measure ID |
|--------------------------------|-------------------------------------------|----------------|
| Boiler Reset Control, Gas      | C&I Existing Building Retrofit (CI_RETRO) | GC2a015        |
| Boiler Reset Control (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | GC2a049        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name         | ΔMMBtu |
|----------------------|--------|
| Boiler Reset Control | 35.5   |

#### Baseline Efficiency:

The baseline efficiency case is a boiler without reset controls.

#### High Efficiency:

The high efficiency case is a boiler with reset controls.

#### Measure Life:

The measure life is based on an ACEEE study.<sup>2</sup>

| Measure Name         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------|-----------------|-----|-----|-----|-----|-----|
| Boiler Reset Control | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name         | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Boiler Reset Control | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on study results.<sup>3</sup>

| Measure Name                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Boiler Reset Control           | CI_RETRO        | All | 0.37 | 0.00            | 0.32             | 0.66 |
| Boiler Reset Control (Turnkey) | CI_RETRO        | All | 0.29 | 0.00            | 0.00             | 0.72 |

**Non-Energy Impacts:**

NEIs are based on study results.<sup>4</sup>

| Measure Name         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Boiler Reset Control | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.863            |                       |

**Endnotes:**

**1** : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Study assumes 710.46 MMBTU base use with 5% savings factor.

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

**2** : ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls.

[ACEEE 2006 Emerging Technologies Report Advanced Boiler Controls](#)

### 3.32. HVAC - Circulator Pump

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-CP                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Replace on Burnout                       |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Single-phase circulator pumps up used in C&I buildings used for hydronic heating and system hot water.

#### BCR Measure IDs:

| Measure Name                | Core Initiative                            | BCR Measure ID |
|-----------------------------|--------------------------------------------|----------------|
| Midstream - Circulator Pump | C&I New & Replacement Equipment (CI_EQUIP) | EC2b057        |

#### Algorithms for Calculating Primary Energy Impact:

Savings depend on application and pump size as described in table below.<sup>1</sup>

| Size    | Type              | kW                                   | kWh                                  |
|---------|-------------------|--------------------------------------|--------------------------------------|
| <= 1 HP | Hydronic Heating  | $\Delta kW = 0.245 * HPrated + 0.02$ | $\Delta kWh = 1,325 * HPrated + 111$ |
|         | Service Hot Water | $\Delta kW = 0.245 * HPrated + 0.02$ | $\Delta kWh = 2,780 * HPrated + 233$ |
| > 1 HP  | Hydronic Heating  | $\Delta kW = 0.265$                  | $\Delta kWh = 1,436$                 |
|         | Service Hot Water | $\Delta kW = 0.265$                  | $\Delta kWh = 3,013$                 |

#### Baseline Efficiency:

The baseline system is a pump without an EC motor. The baseline system may have no control, a timer, aquastat, or be on demand. The baseline system is assumed to run a weighted average of these four control types.

#### High Efficiency:

The high efficiency case is a circulator pump with an ECM.

#### Measure Life:

This is a single baseline measure. The baseline is derived from the new construction baseline for motors.<sup>2</sup>

| Measure Name    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|-----|
| Circulator Pump | CI_EQUIP        | All | 20  | n/a | n/a | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Circulator Pump | CI_EQUIP        | All | 1.00 | 1.01            | n/a              | 1.09             | 1.57             | 0.82             | 0.05             |

### In-Service Rates:

All installations have 100% in-service rates since PA programs include verification of equipment installations.

### Realization Rates:

RRs are from an impact evaluation 2006 HVAC installations.<sup>3</sup>

### Coincidence Factors:

Coincidence factors are based on best information available.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

Statewide net impact factors are based on an Upstream HVAC Net-to-Gross study in Massachusetts in 2021.<sup>5</sup>

| Measure Name                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| HVAC Upstream - Circulator Pump - 2022 | CI_EQUIP        | All | 0.45 | 0.00            | 0.00             | 0.55 |
| HVAC Upstream - Circulator Pump - 2023 | CI_EQUIP        | All | 0.45 | 0.00            | 0.00             | 0.55 |
| HVAC Upstream - Circulator Pump - 2024 | CI_EQUIP        | All | 0.45 | 0.00            | 0.00             | 0.55 |

### Non-Energy Impacts:

| Measure Name           | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|------------------------|-----------------|-----|-------------------|---------------------|
| HVAC - Circulator Pump | CI_EQUIP        | All | \$0.247           |                     |

### Endnotes:

1 : The Cadmus Group (2017). Circulator Pump Technical Memo.

[Cadmus 2017 Circulator Pump Technical Memo](#)

2 : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

3 : RLW Analytics (2008). Business & Construction Solutions (BS/CS) Programs Measurement & Verification 2006 Final Report.

[RLW 2008 Business and Construction Solutions Programs Measurement and Verification 2006 Final Report](#)

4 : MA Common Assumption

**5** : DNV GL (2018). Commercial and Industrial Upstream HVAC/Heat Pump and Hot Water NTG and Market Effects Indicator Study. [2018 DNVGL Upstream HVAC NTG](#)

### 3.33. HVAC - Combo Condensing Boiler/Water Heater

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-CWHB                            |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | New Construction, Retrofit               |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.

#### BCR Measure IDs:

| Measure Name                                                  | Core Initiative                                  | BCR Measure ID |
|---------------------------------------------------------------|--------------------------------------------------|----------------|
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a026        |
| Heating System, Combo Condensing Boiler/Water Heater, Gas 95% | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b018        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name                                   | $\Delta$ MMBtu |
|------------------------------------------------|----------------|
| Combo Condensing Boiler/Water Heater, 95% AFUE | 30.5           |

#### Baseline Efficiency:

The baseline efficiency case is a standard efficiency gas-fired storage tank hot water heater with a separate standard efficiency boiler for space heating purposes.

#### High Efficiency:

The high efficiency case is either a condensing, integrated water heater/boiler with an AFUE of  $\geq 90\%$  or AFUE  $\geq 95\%$ .

#### Measure Life:

The measure life is 20 years.<sup>2</sup>



| Measure Name                         | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|--------------------------------------|----------------------|-----|-----|-----|-----|-----|
| Combo Condensing Boiler/Water Heater | CI_NB&MR<br>CI_EQUIP | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                         | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Combo Condensing Boiler/Water Heater | CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Impact factors come from the 2021 C&I NTG evaluations.<sup>3</sup>

| Measure Name                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Combo Condensing Boiler/Water Heater | CI_NB&MR        | All | 0.58 | 0.22            | 0.00             | 0.64 |
| Combo Condensing Boiler/Water Heater | CI_Equip        | All | 0.37 | 0.026           | 0.19             | 0.84 |

**Non-Energy Impacts:**

Non-energy impact factors come from the 2021 C&I NEI evaluation.<sup>4</sup>

| Measure Name       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Condensing Boilers | CI_NB&MR        | All |                    |                      |                   |                     | \$ 0.846            |                       |

**Endnotes:**

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- 1 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 2 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 3 : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)

### 3.34. HVAC - Combo Furnace/Water Heater

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-CFWH                            |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a combination furnace.

#### BCR Measure IDs:

| Measure Name                                               | Core Initiative                            | BCR Measure ID |
|------------------------------------------------------------|--------------------------------------------|----------------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas | C&I New & Replacement Equipment (CI_EQUIP) | GC2b042        |

#### Algorithms for Calculating Primary Energy Impact:

The heating load for furnaces is 584 therms. This is based on an evaluation of heating equipment installed through the HEHE program and assumed to be representative of single family homes.<sup>1</sup>

$$\Delta \text{ Therms} = \text{heating load} * (1/\text{AFUE}_{\text{base}} - 1/\text{AFUE}_{\text{ee}}) = 584 * (1/0.85 - 1/0.97) = 85 \text{ therms.}$$

The water heating load is 139 therms.<sup>2</sup>

$$\Delta \text{ Therms} = \text{water heating load} * (1/\text{UEF}_{\text{base}} - 1/\text{UEF}_{\text{ee}}) = 139 * (1/0.63 - 1/0.90) = 66 \text{ therms.}$$

| Measure Name                                               | ΔMMBtu/Unit |
|------------------------------------------------------------|-------------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas | 15.1        |

#### Baseline Efficiency:

It is assumed that the baseline is an 85% AFUE furnace and a separate high draw gas fired storage water heater with an efficiency rating of 0.63 UEF.<sup>3</sup>

#### High Efficiency:

A new combination 97% AFUE furnace and 0.90 tankless water heater.

**Measure Life:**

The measure life is 18 years.<sup>4</sup>

| Measure Name                                               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Heating System, Combo Condensing Furnace/Water Heater, Gas | CI_EQUIP        | All | 18  | n/a | n/a | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

2021 C&I NTG study.<sup>5</sup>

| Measure Name                                               | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|------------------------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Heating System, Combo Condensing Furnace/Water Heater, Gas | CI_EQUIP        | All | 0.373 | 0.026           | 0.191            | 0.844 |

**Non-Energy Impacts:**

| Measure Name                      | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|-----------------------------------|-----------------|-----|-------------------|---------------------|
| HVAC - Combo Furnace/Water Heater | CI_EQUIP        | All |                   | \$0.846             |

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**Endnotes:**

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- 1** : The Cadmus Group (2015). High Efficiency Heating Equipment Impact Evaluation.  
[CADMUS 2014 HEHE Impact Evaluation](#)
- 2** : Navigant Consulting (2018). Water Heater, Boiler, and Furnace Cost Study  
[2018 Navigant Water Heater Analysis Memo](#)
- 3** : Values per Residential baseline assumptions informed by negotiations b/w Residential evaluation stakeholders.
- 4** : Environmental Protection Agency (2009). Lifecycle Cost Estimate for Energy Star Furnace.  
[EPA 2009 Lifecycle Cost Estimate for ENERGY STAR Furnace](#)
- 5** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study.

### 3.35. HVAC - Communicating Thermostat

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-WT                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

A communicating thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems

#### BCR Measure IDs:

| Measure Name                                    | Core Initiative                           | BCR Measure ID |
|-------------------------------------------------|-------------------------------------------|----------------|
| Wi-Fi Thermostat, Electric (Turnkey)            | C&I Existing Building Retrofit (CI_RETRO) | EC2a150        |
| Wi-Fi Thermostat, Oil (Turnkey)                 | C&I Existing Building Retrofit (CI_RETRO) | EC2a128        |
| Wi-Fi Thermostat, Propane (Turnkey)             | C&I Existing Building Retrofit (CI_RETRO) | EC2a129        |
| Wi-Fi Thermostat, AC Only (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a085        |
| Wi-Fi Thermostat, Oil (Residential End Use)     | C&I Existing Building Retrofit (CI_RETRO) | EC2a086        |
| Wi-Fi Thermostat, Other (Residential End Use)   | C&I Existing Building Retrofit (CI_RETRO) | EC2a087        |
| Wi-Fi Thermostat, Gas                           | C&I Existing Building Retrofit (CI_RETRO) | GC2a017        |
| Wi-Fi Thermostat, Gas (Turnkey)                 | C&I Existing Building Retrofit (CI_RETRO) | GC2a038        |
| Wi-Fi Thermostat, Gas (Residential End Use)     | C&I Existing Building Retrofit (CI_RETRO) | GC2a068        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results<sup>1</sup>. The total cooling savings of 64 kWh were adjusted to reflect the percent of homes that have cooling which based on the Residential Baseline study is 28 percent.

| Measure Name          | $\Delta kWh$ | $\Delta kW^2$ | $\Delta MMBtu$ |
|-----------------------|--------------|---------------|----------------|
| Wi-Fi Thermostat, Gas |              |               | 2.79           |

|                                                 |    |      |      |
|-------------------------------------------------|----|------|------|
| Wi-Fi Thermostat, Gas (Turnkey)                 |    |      | 2.79 |
| Wi-Fi Thermostat, Gas (Residential End Use)     | 18 | 0.03 | 2.79 |
| Wi-Fi Thermostat, AC Only (Residential End Use) | 64 | 0.10 |      |
| Wi-Fi Thermostat, Oil (Residential End Use)     | 18 | 0.03 | 2.79 |
| Wi-Fi Thermostat, Other (Residential End Use)   | 18 | 0.03 | 2.79 |
| Wi-Fi Thermostat, Oil (Turnkey)                 |    |      | 2.79 |
| Wi-Fi Thermostat, Propane (Turnkey)             |    |      | 2.79 |

### Baseline Efficiency:

The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.

### High Efficiency:

The high efficiency case is an HVAC system that has a Wi-Fi thermostat installed.

### Measure Life:

The measure life is 15 years.<sup>3</sup>

| Measure Name     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------|-----------------|-----|-----|-----|-----|-----|
| Wi-Fi Thermostat | CI_RETRO        | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Wi-Fi Thermostat, Gas                 | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Wi-Fi Thermostat, Gas (Turnkey)       | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Wi-Fi Thermostat, AC Only (High Rise) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |
| Wi-Fi Thermostat, Oil (High Rise)     | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | n/a              | n/a              |
| Wi-Fi Thermostat, Other (High Rise)   | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | n/a              |
| Wi-Fi Thermostat, Gas (High Rise)     | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.37             | 0.00             |
| Wi-Fi Thermostat, Oil (Turnkey)       | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

|                                     |          |     |      |     |      |     |     |     |     |
|-------------------------------------|----------|-----|------|-----|------|-----|-----|-----|-----|
| Wi-Fi Thermostat, Propane (Turnkey) | CI_RETRO | All | 1.00 | n/a | 1.00 | n/a | n/a | n/a | n/a |
|-------------------------------------|----------|-----|------|-----|------|-----|-----|-----|-----|

**In-Service Rates:**

All PAs assume 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors for attached low rise and high rise is based on evaluation results.<sup>5 6</sup>

| Measure Name                                | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|---------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Wi-Fi Thermostat, Gas                       | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.663 |
| Wi-Fi Thermostat, Gas (Turnkey)             | CI_RETRO        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Wi-Fi Thermostat (Residential End Use), Gas | CI_RETRO        | All | 0.14  | 0.0             | 0.0              | 0.86  |
| Wi-Fi Thermostat (Residential End Use)      | CI_RETRO        | All | 0.14  | 0.0             | 0.0              | 0.86  |
| Wi-Fi Thermostat, Oil (Turnkey)             | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Wi-Fi Thermostat, Propane (Turnkey)         | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |



### Non-Energy Impacts:

C&I values from 2021 C&I NEI study.<sup>6</sup> Residential NEI values are rolled up, component values can be found in Appendix B. The Residential End Use value is per household and is adjusted for number of thermostats per account.

| Measure Name                                    | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Wi-Fi Thermostat, Electric (Turnkey)            | CI_RETRO        | All |                    |                      | \$ 0.25           |                     |                     |                       |
| Wi-Fi Thermostat, Oil (Turnkey)                 | CI_RETRO        | All |                    |                      | \$ 0.25           |                     |                     |                       |
| Wi-Fi Thermostat, Propane (Turnkey)             | CI_RETRO        | All |                    |                      | \$ 0.25           |                     |                     |                       |
| Wi-Fi Thermostat, AC Only (Residential End Use) | CI_RETRO        | All | \$14.35            |                      |                   |                     |                     |                       |
| Wi-Fi Thermostat, Oil (Residential End Use)     | CI_RETRO        | All | \$14.35            |                      |                   |                     |                     |                       |
| Wi-Fi Thermostat, Other (Residential End Use)   | CI_RETRO        | All | \$14.35            |                      |                   |                     |                     |                       |
| Wi-Fi Thermostat, Gas                           | CI_RETRO        | All |                    |                      |                   |                     | \$ 2.80             |                       |
| Wi-Fi Thermostat, Gas (Turnkey)                 | CI_RETRO        | All |                    |                      |                   |                     | \$ 2.80             |                       |
| Wi-Fi Thermostat, Gas (Residential End Use)     | CI_RETRO        | All |                    |                      |                   |                     | \$ 2.80             |                       |

### Endnotes:

**2** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**3** : Assumed to have the same lifetime as a regular programmable thermostat. Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat.

[EPA 2010 Lifecycle Cost Estimate for ENERGY STAR Programmable Thermostats](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**5** : NMR (2021) Prescriptive and Custom NTG Omnibus Study [2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)

**6** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures Workbook [2021 Guidehouse MA Res NTG Final Results Workbook](#)

### 3.36. HVAC - Condensing Boiler

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-B                               |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

The installation of a high efficiency natural gas fired condensing hot water boiler. High-efficiency condensing boilers can take advantage of improved design, sealed combustion and condensing flue gases in a second heat exchanger to achieve improved efficiency.

#### BCR Measure IDs:

| Measure Name                                                              | Core Initiative                            | BCR Measure ID |
|---------------------------------------------------------------------------|--------------------------------------------|----------------|
| Heating System, Condensing Boiler, Gas <= 300 mbh (.95 TE)                | C&I New & Replacement Equipment (CI_EQUIP) | GC2b011        |
| Heating System, Condensing Boiler, Gas <= 300 mbh (.90 TE)                | C&I New & Replacement Equipment (CI_EQUIP) | GC2b012        |
| Heating System, Condensing Boiler, Gas 301-499 mbh (.90 TE)               | C&I New & Replacement Equipment (CI_EQUIP) | GC2b013        |
| Heating System, Condensing Boiler, Gas 500-999 mbh (.90 TE)               | C&I New & Replacement Equipment (CI_EQUIP) | GC2b014        |
| Heating System, Condensing Boiler, Gas 1000-1700 mbh (.90 TE)             | C&I New & Replacement Equipment (CI_EQUIP) | GC2b015        |
| Heating System, Condensing Boiler, Gas 1701+ mbh (.90 TE), Gas            | C&I New & Replacement Equipment (CI_EQUIP) | GC2b016        |
| Heating System, Condensing Boiler, Gas < = 300 mbh (0.90 TE) - Upstream   | C&I New & Replacement Equipment (CI_EQUIP) | GC2b045        |
| Heating System, Condensing Boiler, Gas 300-499 mbh (0.90 TE) - Upstream   | C&I New & Replacement Equipment (CI_EQUIP) | GC2b046        |
| Heating System, Condensing Boiler, Gas 500-999 mbh (0.90 TE) - Upstream   | C&I New & Replacement Equipment (CI_EQUIP) | GC2b047        |
| Heating System, Condensing Boiler, Gas 1000-1700 mbh (0.90 TE) - Upstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b048        |
| Heating System, Condensing Boiler, Gas 1700+ mbh (0.90 TE) - Upstream     | C&I New & Replacement Equipment (CI_EQUIP) | GC2b049        |

### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name            | ΔMMBtu |
|-------------------------|--------|
| <= 300 mbh (0.95 TE)    | 13.8   |
| <= 300 mbh (0.90 TE)    | 11.4   |
| 301-499 mbh (0.90 TE)   | 21.8   |
| 500-999 mbh (0.90 TE)   | 39.9   |
| 1000-1700 mbh (0.90 TE) | 73.4   |
| 1701+ mbh (0.90 TE)     | 128.5  |

### Baseline Efficiency:

Baseline efficiency is an 85% AFUE boiler.<sup>2</sup>

### High Efficiency:

High efficiency is per table efficiency thresholds above.

### Measure Life:

The measure life is 20 years.<sup>3</sup>

| Measure Name       | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------|-----------------|-----|-----|-----|-----|-----|
| Condensing Boilers | CI_EQUIP        | All | 20  | n/a | n/a | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Condensing Boilers | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

### In-Service Rates:

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rates. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net to Gross factors based on study results.<sup>4</sup>

| Measure Name       | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------|-----------------|-----|------|-----------------|------------------|------|
| Condensing Boilers | CI_EQUIP        | All | 0.37 | 0.026           | 0.19             | 0.84 |

**Non-Energy Impacts:**

Non Energy Impact factors are deemed from the study results.<sup>5</sup>

| Measure Name       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Condensing Boilers | CI_NB&MR        | All |                    |                      |                   |                     | \$ 0.846            |                       |

**Endnotes:**

- 
- 2 : DNVGL,NMR Group, 2017, Gas Boiler Market Characterization  
[DNVGL 2017 Gas Boiler Market Characterization](#)  
 3 : [MA19C02 B EUL-final-report-03\\_31\\_20-v2](#)

### 3.37. HVAC - Condensing Unit Heater

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-CUH                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.

#### BCR Measure IDs:

| Measure Name                           | Core Initiative                                  | BCR Measure ID |
|----------------------------------------|--------------------------------------------------|----------------|
| Condensing Unit Heater, Gas <= 300 mbh | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a023        |
| Condensing Unit Heater, Gas <= 300 mbh | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b019        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings for the heaters are deemed based on study results.<sup>1</sup>

| Measure Name                        | $\Delta$ MMBtu |
|-------------------------------------|----------------|
| Condensing Unit Heater (<= 300 mbh) | 40.9           |

#### Baseline Efficiency:

The baseline efficiency case for the unit heater is a standard efficiency gas fired unit heater with minimum combustion efficiency of 80%, interrupted or intermittent ignition device (IID), and either power venting or an automatic flue damper<sup>2</sup>.

#### High Efficiency:

The high efficiency case is a condensing gas unit heater with 90% AFUE or greater.

**Measure Life:**

The measure life is 18 years<sup>3</sup> for the unit heater.

| Measure Name           | Core Initiative    | PA  | EUL | OYF | RUL | AML |
|------------------------|--------------------|-----|-----|-----|-----|-----|
| Condensing Unit Heater | CI_NB&MR, CI_EQUIP | All | 18  | n/a | n/a | 18  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name           | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Condensing Unit Heater | CI_NB&MR<br>CI_EQUIP | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors align with the loadshapes used to capture the coincident peak demand savings associated with the scroll compressor and the floating head pressure control components of the measure, as used in the VT TRM methodology.

**Impact Factors for Calculating Net Savings:**

Net savings factors for Condensing Boilers within CI\_NB&MR initiative are from the 2021 NRNC NTG study (paths 3&4). Condensing Boilers within CI\_EQUIP initiative are based on evaluated freeridership and spillover factors for Massachusetts prescriptive C&I New and Replacement Equipment (2021 Omnibus NTG Study).

| Measure Name       | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Condensing Boilers | CI_NB&MR        | All | 0.583 | 0.227           |                  | 0.644 |
| Condensing Boilers | CI_EQUIP        | All | 0.373 | 0.026           | 0.191            | 0.844 |

**Non-Energy Impacts:**

Impact factors are deemed based on study results.<sup>5</sup>

| Measure Name           | Core Initiative    | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------|--------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Condensing Unit Heater | CI_NB&MR, CI_EQUIP | All |                    |                      |                   |                     | \$0.846             |                       |

**Endnotes:**

**2** : 2012 International Energy Conservation Code

**3** : Ecotrope, Inc. (2003). Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial Sectors. Prepared for the Energy Trust of Oregon.

[Ecotrope 2003 Natural Gas Efficiency and Conservation Measure Resource Assessment](#)

**5** : KEMA (2012). Commercial and Industrial Non-Energy impacts Study.

[TETRATECH 2012 MA CI NEI REPORT](#)

### 3.38. HVAC - Cooler Night Cover

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-CNC     |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

Installation of retractable aluminum woven fabric covers for open-type refrigerated display cases, where the covers are deployed during the facility unoccupied hours in order to reduce refrigeration energy consumption.

#### BCR Measure IDs:

| Measure Name        | Core Initiative                           | BCR Measure ID |
|---------------------|-------------------------------------------|----------------|
| Cooler Night Covers | C&I Existing Building Retrofit (CI_RETRO) | E19C2a038      |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (\text{Width}) \times (\text{Save}) \times (\text{Hours})$$

$$\Delta kW = (\text{Width}) \times (\text{Save})$$

Where:

$\Delta kWh$  = Energy Savings

$\Delta kW$  = Connected load reduction

Width = Width of the opening that the night covers protect (ft)

Save = Savings factor based on the temperature of the case (kW/ft). See table below<sup>1</sup>

Hours = Annual hours that the night covers are in use

#### Savings Factors:

| Cooler Case Temperature          | Savings Factor |
|----------------------------------|----------------|
| Low Temperature (-35 F to -5 F)  | 0.03 kW/ft     |
| Medium Temperature (0 F to 30 F) | 0.02 kW/ft     |
| High Temperature (35 F to 55 F)  | 0.01 kW/ft     |

#### Baseline Efficiency:

The baseline efficiency case is the annual operation of open-display cooler cases.



**High Efficiency:**

The high efficiency case is the use of night covers to protect the exposed area of display cooler cases during unoccupied hours.

**Measure Life:**

The measure is determined to be an add on single baseline measure.<sup>2 3</sup>

| Measure Name                        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - Cooler Night Covers | CI_RETRO        | All | 10  | 1   | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                        | Core Initiative | PA         | ISR  | RR <sub>E</sub> <sup>6</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| Refrigeration - Cooler Night Covers | CI_RETRO        | ES, Unitil | 1.00 | 0.95                         | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration - Cooler Night Covers | CI_RETRO        | NGRID, CLC | 1.00 | 1.05                         | 1.00             | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs’ programs include verification of equipment installations.

**Realization Rates:**

Values based on small business non-lighting study (2019)

**Coincidence Factors:**

Coincidence factors are representative of C&I Refrigeration

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>5</sup>

| Measure Name                        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Refrigeration - Cooler Night Covers | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |

**Non-Energy Impacts:**

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>6</sup>

| Measure Name                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - Cooler Night Covers | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

**Endnotes:**

**1** : CL&P Program Savings Documentation for 2011 Program Year (2010). Factors based on Southern California Edison (1997). Effects of the Low Emissive Shields on Performance and Power Use of a Refrigerated Display Case.

[SoCalEdison 1997 Effects of the Low Emissive Shields on Performance and Power Use of a Refrigerated Display Case](#)

**2** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.

[2018 DNVGL ERS Portfolio Model Companion Sheet](#)

**3** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Page 4-5 to 4-6. [ERS 2005 Measure Life Study](#)

**6** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures. [Final Report MA19C03-E-SBIMPCT 03202020](#)

**5** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study. [2021 NMR C&I Omnibus NTG](#)

**6** : MA20X10-B-CIOMNEI

### 3.39. HVAC - Dual Enthalpy Economizer Controls (DEEC)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-DEEC                            |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

The measure is to upgrade the outside-air dry-bulb economizer to a dual enthalpy economizer. The system will continuously monitor the enthalpy of both the outside air and return air. The system will control the system dampers adjust the outside quantity based on the two readings.

#### BCR Measure IDs:

| Measure Name                                         | Core Initiative                            | BCR Measure ID |
|------------------------------------------------------|--------------------------------------------|----------------|
| Midstream - Dual Enthalpy Economizer Controls (DEEC) | C&I New & Replacement Equipment (CI_EQUIP) | EC2b054        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (kBtu/h)(1 \text{ Ton}/12 \text{ kBtu} / h)(SAVEkWh)$$

$$\Delta kWh = (kBtu/h)(1 \text{ Ton}/12 \text{ kBtu} / h)(SAVEkW)$$

Where:

kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12kBtu/h).

SAVEkWh = Average annual kWh reduction per ton of cooling capacity: 289 kWh/ton<sup>1</sup>

SAVEkW = Average kW reduction per ton of cooling capacity: 0.289 kW/ton<sup>2</sup>

#### Baseline Efficiency:

The baseline efficiency case for this measure assumes the relevant HVAC equipment is operating with a fixed dry-bulb economizer.

#### High Efficiency:

The high efficiency case is the installation of an outside air economizer utilizing two enthalpy sensors, one for outdoor air and one for return air.

#### Measure Life:

The measure life is 10 years.<sup>3</sup>

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure | Core Initiative | PA                 | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------|-----------------|--------------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| DEEC    | CI_EQUIP        | National Grid      | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.40             | 0.00             |
| DEEC    | CI_EQUIP        | Eversource (NSTAR) | 1.00 | 1.01            | n/a              | 1.09             | 1.57             | 0.45             | 0.00             |
| DEEC    | CI_EQUIP        | CLC                | 1.00 | 1.01            | n/a              | 1.09             | 1.57             | 0.44             | 0.00             |
| DEEC    | CI_EQUIP        | Unitil             | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.332            | 0.00             |

**In-Service Rates:**

All installations have 100% in-service rates since PA programs include verification of equipment installations.

**Realization Rates:**

- National Grid RRs are 1.0 since there have been no impact evaluations of the prescriptive savings calculations.
- Eversource (NSTAR) & CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations.<sup>4</sup>
- Unitil realization rates same as Unitary AC.

**Coincidence Factors:**

- All PAs on-peak CFs based 2011 NEEP C&I Unitary AC Loadshape Project<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

| Measure                                                  | Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------------------------|------------|-----|------|-----------------|------------------|------|
| HVAC Upstream - Dual Enthalpy Economizer Controls - 2022 | CI_EQUIP   | All | 0.45 | 0.00            | 0.00             | 0.55 |
| HVAC Upstream - Dual Enthalpy Economizer Controls - 2023 | CI_EQUIP   | All | 0.45 | 0.00            | 0.00             | 0.55 |
| HVAC Upstream - Dual Enthalpy Economizer Controls - 2024 | CI_EQUIP   | All | 0.45 | 0.00            | 0.00             | 0.55 |

NTG rates are based on the Massachusetts Commercial and Industrial Upstream HVAC/Heat Pump and Hot Water NTG and Market Effects Indicator Study. Dual Enthalpy Economizer Controls (DEEC) were not studied specifically, but the value from HVAC Upstream Unitary Air Conditioners was applied to this equipment.<sup>6</sup>

**Non-Energy Impacts:**

| Measure Name                             | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|------------------------------------------|-----------------|-----|-------------------|---------------------|
| Dual Enthalpy Economizer Controls (DEEC) | CL_EQUIP        | All | \$0.194           |                     |

**Endnotes:**

- 1** : Patel, Dinesh (2001). Energy Analysis: Dual Enthalpy Control. Prepared for Eversource (NSTAR). [Patel 2001 Energy Analysis Dual Enthalpy Controls](#)
- 2** : Patel, Dinesh (2001). Energy Analysis: Dual Enthalpy Control. Prepared for Eversource (NSTAR). [Patel 2001 Energy Analysis Dual Enthalpy Controls](#)
- 3** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1 [ERS 2005 Measure Life Study](#)
- 4** : KEMA (2011). C&I Unitary HVAC Loadshape Project - Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum. [KEMA 2011 CIUnitaryHVACLoadShapeProject](#)
- 5** : KEMA (2011). C&I Unitary HVAC Loadshape Project - Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum. [KEMA 2011 CIUnitaryHVACLoadShapeProject](#)
- 6** : DNV GL Inc., NMR Group Inc., and Tetra Tech, Inc. (2018). Massachusetts Commercial and Industrial Upstream HVAC/Heat Pump and Hot Water NTG and Market Effects Indicator Study. [2018 DNVGL Upstream HVAC NTG](#)

### 3.40. HVAC - Duct Insulation

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-DI                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

For existing ductwork in non-conditioned spaces, insulate ductwork. This could include replacing un-insulated flexible duct with rigid insulated ductwork and installing 1" - 2" of duct-wrap insulation.

#### BCR Measure IDs:

| Measure Name                        | Core Initiative                           | BCR Measure ID |
|-------------------------------------|-------------------------------------------|----------------|
| Duct Insulation, Electric (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a130        |
| Duct Insulation, Oil (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a131        |
| Duct Insulation, Propane (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO) | EC2a132        |
| Duct Insulation, Gas                | C&I Existing Building Retrofit (CI_RETRO) | GC2a019        |
| Duct Insulation, Gas (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a041        |

#### Algorithms for Calculating Primary Energy Impact:

Per sq ft savings based on PA internal calculations.<sup>1</sup>

| Measure Name              | $\Delta$ kWh/sq ft | $\Delta$ kW/sq ft | $\Delta$ MMBtu/sq ft |
|---------------------------|--------------------|-------------------|----------------------|
| Duct Insulation, Gas      |                    |                   | 0.035                |
| Duct Insulation, Electric | 13                 | 0.01              |                      |
| Duct Insulation, Oil      |                    |                   | 0.035                |
| Duct Insulation, Propane  |                    |                   | 0.035                |

#### Baseline Efficiency:

The baseline efficiency case is existing, uninsulated ductwork in unconditioned spaces (e.g. attic or basement).

#### High Efficiency:

The high efficiency condition is insulated ductwork in unconditioned spaces.

### Measure Life:

The measure life is 20 years.<sup>2</sup>

| Measure Name    | Core Initiative | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|
| Duct Insulation | CI_RETRO        | 20  | n/a | n/a | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name              | Core Initiative | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------|-----------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Insulation, Gas      | CI_RETRO        | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Insulation, Electric | CI_RETRO        | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.81             |
| Duct Insulation, Oil      | CI_RETRO        | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Duct Insulation, Propane  | CI_RETRO        | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

All PAs use 100% energy, demand, and non-energy realization rates.

### Coincidence Factors:

Factors based on the residential demand impact model.<sup>3</sup>

### Impact Factors for Calculating Net Savings:

Impact factors are from the 2021 C&I NTG evaluation.<sup>4</sup>

| Measure Name                        | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Duct Insulation, Gas                | CI_Retro        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Duct Insulation, Gas (Turnkey)      | CI_RETRO        | All | 0.369 | 0.00            | 0.032            | 0.663 |
| Duct Insulation, Electric (Turnkey) | CI_Retro        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Duct Insulation, Oil (Turnkey)      | CI_Retro        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Duct Insulation, Propane (Turnkey)  | CI_Retro        | All | 0.077 | 0.013           | 0.004            | 0.940 |

**Non-Energy Impacts:**

Non-energy impact factors come from the 2021 C&I NEI evaluation<sup>5</sup>

| Measure Name                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Insulation, Gas                | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.593            |                       |
| Duct Insulation, Gas (Turnkey)      | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.593            |                       |
| Duct Insulation, Electric (Turnkey) | CI_RETRO        | All |                    |                      | 0.14              |                     |                     |                       |
| Duct Insulation, Oil (Turnkey)      | CI_RETRO        | All |                    |                      | 0.14              |                     |                     |                       |
| Duct Insulation, Propane (Turnkey)  | CI_RETRO        | All |                    |                      | 0.14              |                     |                     |                       |

**Endnotes:**

- 1 : [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)  
 3 : [2018 Navigant Baseline Loadshape Comprehensive Report](#)



### 3.41. HVAC - Duct Insulation - C&I Metered Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-DIREU                           |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

For existing ductwork in non-conditioned spaces, seal and insulate ductwork. This could include replacing un-insulated flexible duct with rigid insulated ductwork or sealing leaky fixed ductwork with mastic or aerosol and installing 1” – 2” of duct-wrap insulation.

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                           | BCR Measure ID |
|---------------------------------------------|-------------------------------------------|----------------|
| Duct Insulation, Elec (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a065        |
| Duct Insulation, Gas (Residential End Use)  | C&I Existing Building Retrofit (CI_RETRO) | GC2a059        |

#### Algorithms for Calculating Primary Energy Impact:

Deemed average annual MMBtu savings of 0.035 are assumed per unit.<sup>1</sup> Units are based on square feet of duct surface area.

#### Baseline Efficiency:

The baseline efficiency case is existing, uninsulated ductwork in unconditioned spaces (e.g. attic or basement).

#### High Efficiency:

The high efficiency condition is insulated ductwork in unconditioned spaces.

#### Measure Life:

The measure life is 20 years.<sup>2</sup>

| Measure Name                          | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Duct Insulation (Residential End Use) | CI_RETRO        | All | 20  | n/a | n/a | 20  |

#### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Insulation, Gas (Residential End Use)  | CI_RETRO        | All | 1.00 | 0.86            | 0.86             | 1.00             | 1.00             | n/a              | n/a              |
| Duct Insulation, Elec (Residential End Use) | CI_RETRO        | All | 1.00 | 0.86            | 1.00             | 0.86             | 0.86             | 0.37             | 0.22             |

**In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on evaluation results.<sup>3</sup>

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-gross factors are from evaluation results.<sup>5</sup>

| Measure Name                                | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Insulation, Gas (Residential End Use)  | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |
| Duct Insulation, Elec (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

**1** : National Grid Staff Estimate (2010) MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)

**2** : National Grid Staff Estimate (2010) MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)

**3** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

**5** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products. [2021 Guidehouse MA Res NTG Final Report](#)

### 3.42. HVAC - Duct Sealing

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-DS                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

For existing ductwork in non-conditioned spaces, seal ductwork. This could include sealing leaky fixed ductwork with mastic or aerosol.

#### BCR Measure IDs:

| Measure Name                | Core Initiative                           | BCR Measure ID |
|-----------------------------|-------------------------------------------|----------------|
| Duct Sealing, Gas           | C&I Existing Building Retrofit (CI_RETRO) | GC2a020        |
| Duct Sealing, Gas (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | GC2a040        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results:

$$\Delta\text{MMBtu} = \text{MMBtu} \times \text{Units}$$

Where:

Unit = Number of square feet of ductwork treated

MMBtu = Average annual MMBtu savings per unit: 0.094<sup>1</sup>

#### Baseline Efficiency:

The baseline efficiency case is existing, non-sealed (leaky) in unconditioned spaces (e.g. attic or basement).

#### High Efficiency:

The high efficiency condition is air sealed ductwork in unconditioned spaces.

#### Measure Life:

The measure life is 20 years.<sup>2</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Duct Sealing | CI_RETRO        | All | 20  | n/a | n/a | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Sealing | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

### Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

### Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.<sup>3</sup>

| Measure Name           | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Duct Sealing           | CI_RETRO        | All | 0.221 | 0.025           | 0.00             | 0.660 |
| Duct Sealing (Turnkey) | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.720 |

### Non-Energy Impacts:

Non-energy impact factors come from the 2021 C&I NEI evaluation<sup>4</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Sealing | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.593            |                       |

### Endnotes:

**1** : National Grid Staff Estimate (2010). MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)

**2** : National Grid Staff Estimate (2010). MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. [NGrid MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings 6-22-10](#)

### 3.43. HVAC - Duct Sealing - C&I Metered Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-DS-REU                          |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Ducts are sealed by reconnecting disconnected duct joints and sealing gaps or seams with mastic and fiber-mesh tape as appropriate.

#### BCR Measure IDs:

| Measure Name                             | Core Initiative                           | BCR Measure ID |
|------------------------------------------|-------------------------------------------|----------------|
| Duct Sealing, Elec (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a064        |
| Duct Sealing, Gas (Residential End Use)  | C&I Existing Building Retrofit (CI_RETRO) | GC2a058        |

#### Algorithms for Calculating Primary Energy Impact:

$$\text{MMBtu} = \text{Annual Heating Consumption} \times \% \text{SAVE} \times 1/1,000,000$$

Where:

AnnualHeatingConsumption = The total annual heating consumption for the facility (Btu)

%SAVE = Average reduction in energy consumption.

1/1,000,000 = Conversion from Btu to MMBtu.

#### Savings Factors for Multifamily Duct Sealing:

| Measure Type                          | %SAVE <sup>1</sup> |
|---------------------------------------|--------------------|
| Surface Area < 50 SQFT                | 7%                 |
| Surface Area > 50 SQFT and < 200 SQFT | 3%                 |
| Surface Area > 200 SQFT               | 1%                 |

#### Baseline Efficiency:

The baseline efficiency case is the existing facility or equipment prior to the implementation of duct sealing.

### High Efficiency:

The baseline efficiency case is the existing facility or equipment after the implementation of duct sealing.

### Measure Life:

The measure life is 20 years.<sup>2</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Duct Sealing | CI_RETRO        | All | 20  | n/a | n/a | 20  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Duct Sealing | CI_RETRO        | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.37             | 0.22             |

### In-Service Rates:

In-service rates are set to 100% for direct install measures.

### Realization Rates:

The energy realization rate is based on evaluation results.<sup>3</sup>

### Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

Net to gross factors based on evaluation results.<sup>5</sup>

| Measure Name | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------|-----------------|-----|------|-----------------|------------------|------|
| Duct Sealing | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.<sup>6</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Duct Sealing | CI_RETRO        | All | 0.23               | 0.00                 | 0.00              | 0.00                | 0.00                | 0.00                  |

**Endnotes:**

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**1** : Savings assumptions from National Grid program vendor.

**2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**3** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation

[2018 Navigant Multifamily Program Impact Evaluation](#)

**4** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**5** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.

[2021 Guidehouse MA Res NTG Final Report](#)

**6** : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation.

[Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)

### 3.44. HVAC - Ducted Heat Pump Displacing Oil/Propane Heating

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-XXZ                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Partial displacement of an existing inefficient propane or oil furnace with a high efficiency central ducted heat pump with a cooling capacity <65,000 kBtu/h.

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                            | BCR Measure ID |
|---------------------------------------------|--------------------------------------------|----------------|
| Ducted Heat Pump displacing Oil Heating     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b104        |
| Ducted Heat Pump displacing Propane Heating | C&I New & Replacement Equipment (CI_EQUIP) | EC2b106        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a model developed to estimate the savings associated with the displacement of existing heating (and cooling) systems by CBECS building type<sup>1</sup>:

kWh Savings = Square footage \* Savings Factor from Lookup table based on building type

Max kW Savings = Square footage \* Savings Factor from Lookup table based on building type

Oil/Propane Savings = Square footage \* Savings Factor from Lookup table based on building type

Where:

Square footage = conditioned area of building that heat pumps are being added to

| Measure Name     | Savings factor                         | Outpatient Health | Office  | Service | Food sales | Retail  | Religious Worship | Restaurant | Public Assembly | Education |
|------------------|----------------------------------------|-------------------|---------|---------|------------|---------|-------------------|------------|-----------------|-----------|
| Ducted Heat Pump | Demand reduction (kW/ft <sup>2</sup> ) | -0.0009           | -0.0007 | -0.0010 | -0.0003    | -0.0006 | -0.0004           | -0.0005    | -0.0003         | -0.0007   |



|                                             |                                          |         |         |         |         |         |         |         |         |         |
|---------------------------------------------|------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| displacing Oil Heating                      | Electric Savings (kWh/ft <sup>2</sup> )  | -2.66   | -2.02   | -3.06   | -0.89   | -1.66   | -1.20   | -1.41   | -0.81   | -2.04   |
|                                             | Oil Savings (MMbtu/ft <sup>2</sup> )     | 0.028   | 0.021   | 0.032   | 0.009   | 0.017   | 0.012   | 0.015   | 0.008   | 0.021   |
| Ducted Heat Pump displacing Propane Heating | Demand reduction (kW/ft <sup>2</sup> )   | -0.0011 | -0.0008 | -0.0013 | -0.0004 | -0.0007 | -0.0005 | -0.0006 | -0.0003 | -0.0009 |
|                                             | Electric Savings (kWh/ft <sup>2</sup> )  | -4.34   | -3.29   | -4.99   | -1.46   | -2.70   | -1.96   | -2.31   | -1.32   | -3.33   |
|                                             | Propane Savings (MMbtu/ft <sup>2</sup> ) | 0.050   | 0.038   | 0.057   | 0.017   | 0.031   | 0.023   | 0.027   | 0.015   | 0.038   |

**Baseline Efficiency:**

For propane the baseline is an existing inefficient furnace at 78% AFUE furnace.<sup>4</sup> For oil the baseline is an existing inefficient furnace at 78% AFUE furnace.<sup>5</sup>

Cooling baseline is a ducted A/C Blended Baseline that includes split AC (14 SEER), package AC (14 SEER), room AC (8 EER) and no AC.<sup>6</sup>

**High Efficiency:**

The high efficiency case is a new 16 SEER/9.5 HSPF ducted central heat pump.

**Measure Life:**

The measure life is based on evaluation results.

| Measure Name                                    | Core Initiative | PA  | EUL <sup>7</sup> | OYF | RUL | AML |
|-------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Ducted Heat Pump displacing Oil/Propane Heating | CI_EQUIP        | All | 17               | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative | PA | ISR | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|----|-----|-----------------|------------------|------------------|------------------|------------------|------------------|
|--------------|-----------------|----|-----|-----------------|------------------|------------------|------------------|------------------|------------------|

|                                             |          |     |      |      |      |      |      |        |      |
|---------------------------------------------|----------|-----|------|------|------|------|------|--------|------|
| Ducted Heat Pump displacing Oil Heating     | CI_EQUIP | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.215 | 0.30 |
| Ducted Heat Pump displacing Propane Heating | CI_EQUIP | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.171 | 0.30 |

**In-Service Rates:**

All installations have 100% in-service rates 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 calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                    | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>9</sup> |
|-------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Ducted Heat Pump displacing Oil/Propane Heating | CI_EQUIP        | All | 0.31 | 0.22            | 0.00             | 0.91             |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

1 : Navigant Consulting (2018). Energy Optimization Study [2018 Navigant Energy Optimization](#)

2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

4 : Agreed upon value with EEAC consultants.

5 : Department of Energy (2011). Federal Register / Vol. 76, No. 123

[http://www1.eere.energy.gov/buildings/appliance\\_standards/pdfs/cacfurn\\_dfr.pdf](http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf)

6 : Navigant Consulting (2018). Baseline Study Saturation Result

[2018 Navigant Baseline Loadshape Comprehensive Report](#)

7 : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting

and HVAC Measures.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

### 3.45. HVAC - Ducted Heat Pump, <5.4 Tons

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-XXX                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a high efficiency central ducted air cooled heat pump unit with cooling capacity less than 65 kBtu/h.

#### BCR Measure IDs:

| Measure Name                | Core Initiative                            | BCR Measure ID |
|-----------------------------|--------------------------------------------|----------------|
| Ducted Heat Pump, <5.4 Tons | C&I New & Replacement Equipment (CI_EQUIP) | EC2b101        |

#### Algorithms for Calculating Primary Energy Impact:

For air cooled units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/h) * (1/SEER_{BASE} - 1/SEER_{EE}) * EFLH_{COOL}$$

$$\Delta kWh_{heat} = (kBtu/h) * (1/HSPF_{BASE} - 1/HSPF_{EE}) * EFLH_{HEAT}$$

$$\Delta kW_{cool} = (kBtu/h)_{Cool} * (1/EER_{BASE} - 1/EER_{EE})$$

#### Where:

SEER<sub>BASE</sub> = Seasonal Energy Efficiency Ratio of baseline HP equipment  
 SEER<sub>EE</sub> = Seasonal Energy Efficiency Ratio of new efficient HP equipment.  
 HSPF<sub>BASE</sub> = Heating Seasonal Performance Factor of baseline HP equipment  
 HSPF<sub>EE</sub> = Heating Seasonal Performance Factor of new efficient HP equipment.  
 EER<sub>BASE</sub> = Energy Efficiency Ratio of baseline HP equipment  
 EER<sub>EE</sub> = Energy Efficiency Ratio of new efficient HP equipment  
 EFLH<sub>COOL</sub> = Cooling mode equivalent full load hours. See notes and table for default values.  
 EFLH<sub>HEAT</sub> = Heating mode equivalent full load hours. See notes and table for default values.

Note: Average cooling EFLHs are from the 2010 NEEP HVAC Loadshape study.<sup>1</sup> PA derived from the NEEP results, weighted based on ISO-NE load zones for each PA. Average cooling hours and Capacity Adjustment Factors derived from the NEEP study to align with use of IEER.

### PA Specific Inputs

| PA      | EFLH <sub>cool</sub> | EFLH <sub>heat</sub> |
|---------|----------------------|----------------------|
| NGRID   | 935                  | 984                  |
| CLC     | 1,172                | 530                  |
| Unitil  | 755                  | 1,329                |
| ES West | 755                  | 1,329                |
| ES East | 1,172                | 530                  |

### Baseline Efficiency:

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by IECC 2018.

Heat Pump Baseline Efficiency Levels:<sup>2</sup>

| Equipment Type | Unit Type | Tier | Size Category          | Sub Category            | Full Load Cooling Efficiency |     | Seasonal/Part Load Cooling Efficiency |     | Heating Efficiency |
|----------------|-----------|------|------------------------|-------------------------|------------------------------|-----|---------------------------------------|-----|--------------------|
| Air-Cooled     | AC or HP  | 1    | < 65 kBtuh (<5.4 Tons) | Split or Package System | 12.0 EER                     | and | 15.0 SEER                             | and | 9.0 HSPF           |
|                |           | 2    |                        |                         | 12.0 EER                     | and | 16.0 SEER                             | and | 9.0 HSPF           |
|                |           | 3    |                        |                         | 12.0 EER                     | and | 17.0 SEER                             | and | 9.0 HSPF           |

### High Efficiency:

The high efficiency case is a new 16 SEER/9.5 HSPF central heat pump.

### Measure Life:

| Measure Name                | Core Initiative | PA  | EUL <sup>3</sup> | OYF | RUL | AML |
|-----------------------------|-----------------|-----|------------------|-----|-----|-----|
| Ducted Heat Pump, <5.4 Tons | CI_EQUIP        | All | 17               | n/a | n/a | 17  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Ducted Heat Pump, <5.4 Tons | CI_EQUIP        | All | 1.00 | 1.00            | n/a              | n/a              | n/a              | 0.31             | 0.81             |

**In-Service Rates:**

All installations have 100% in-service rates 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 <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>8</sup> |
|-----------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Ducted Heat Pump, <5.4 Tons | CI_EQUIP        | All | 0.25 | 0.00            | 0.09             | 0.84             |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

**1** : 2020 NEEP Loadshape Study –

[https://neep.org/sites/default/files/resources/NEEP\\_HVAC\\_Load\\_Shape\\_Report\\_Final\\_August2\\_0.pdf](https://neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf)

**2** : IECC 2018 International Energy Code

**3** : Measure life Air source heat Pump GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

GDS\_2007\_Measure\_Life\_Report\_Residential\_and\_CI\_Lighting\_and\_HVAC\_Measures

**8** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.

[2021 NMR C&I Omnibus NTG](#)

### 3.46. HVAC - Ductless Heat Pump Displacing Electric Resistance

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-XXJ                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Partial displacement of electric resistance heat with a high efficiency ductless minisplit heat pump with a cooling capacity <65,000 kBtu/h.

#### BCR Measure IDs:

| Measure Name                                      | Core Initiative                            | BCR Measure ID |
|---------------------------------------------------|--------------------------------------------|----------------|
| Ductless Heat Pump displacing Electric Resistance | C&I New & Replacement Equipment (CI_EQUIP) | EC2b103        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a model developed to estimate the savings associated with the displacement of existing heating (and cooling) systems by CBECS building type<sup>1</sup>:

kWh Savings = Square footage \* Savings Factor from Lookup table based on building type

Max kW Savings = Square footage \* Savings Factor from Lookup table based on building type

Oil/Propane Savings = Square footage \* Savings Factor from Lookup table based on building type

Where:

Square footage = conditioned area of building that heat pumps are being added to

| Measure Name                                      | Savings factor                          | Outpatient Health | Office | Service | Food sales | Retail | Religious Worship | Restaurant | Public Assembly | Education |
|---------------------------------------------------|-----------------------------------------|-------------------|--------|---------|------------|--------|-------------------|------------|-----------------|-----------|
| Ductless Heat Pump displacing Electric Resistance | Demand reduction (kW/ft <sup>2</sup> )  | 0.0001            | 0.0001 | 0.0001  | 0.0000     | 0.0001 | 0.0001            | 0.0001     | 0.0000          | 0.0001    |
|                                                   | Electric Savings (kWh/ft <sup>2</sup> ) | 7.699             | 5.837  | 8.851   | 2.584      | 4.787  | 3.480             | 4.081      | 2.341           | 5.906     |

**Baseline Efficiency:**

The heating baseline is electric resistance heating.

Cooling baseline is a ducted A/C Blended Baseline that includes split AC (14 SEER), package AC (14 SEER), room AC (8 EER) and no AC.<sup>6</sup>

**High Efficiency:**

The high efficiency case is a new 18 SEER/10 HSPF ductless minisplit heat pump.

**Measure Life:**

The measure life is based on evaluation results.

| Measure Name                                      | Core Initiative | PA  | EUL <sup>7</sup> | OYF | RUL | AML |
|---------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Ductless Heat Pump displacing Electric Resistance | CI_EQUIP        | All | 17               | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Ductless Heat Pump displacing Electric Resistance | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.04            | 0.30             |

**In-Service Rates:**

All installations have 100% in-service rates 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 calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>9</sup> |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Ductless Heat Pump displacing Electric Resistance | CI_EQUIP        | All | 0.25 | 0.00            | 0.09             | 0.84             |



**Non-Energy Impacts:**

Non-energy impacts are based on study results <sup>10</sup>

| Measure Name                                      | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time\$ per Therm |
|---------------------------------------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|----------------------|
| Ductless Heat Pump displacing Electric Resistance | All | \$0.00             | \$0.00               | \$0.14            | \$0.00              | 0.00                | 0.00                 |

**Endnotes:**

**1** : Navigant Consulting (2018). Energy Optimization Study [2018 Navigant Energy Optimization](#)

**2** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**2** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**6** : Navigant Consulting (2018). Baseline Study Saturation Result [2018 Navigant Baseline Loadshape Comprehensive Report](#)

**7** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**9** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study. [2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)

**10** : MA20X10-B-CIOMNEI

### 3.47. HVAC - Ductless Heat Pump Displacing Oil/Propane Heating

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-XXX                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Partial displacement of an existing inefficient propane or oil boiler with a high efficiency ductless minisplit heat pump with a cooling capacity <65,000 kBtu/h.

#### BCR Measure IDs:

| Measure Name                                  | Core Initiative                            | BCR Measure ID |
|-----------------------------------------------|--------------------------------------------|----------------|
| Ductless Heat Pump displacing Oil Heating     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b105        |
| Ductless Heat Pump displacing Propane Heating | C&I New & Replacement Equipment (CI_EQUIP) | EC2b107        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a model developed to estimate the savings associated with the displacement of existing heating (and cooling) systems by CBECS building type <sup>2</sup> :

kWh Savings = Square footage \* Savings Factor from Lookup table based on building type

Max kW Savings = Square footage \* Savings Factor from Lookup table based on building type

Oil/Propane Savings = Square footage \* Savings Factor from Lookup table based on building type

Where:

Square footage = conditioned area of building that heat pumps are being added to

| Measure Name       | Savings factor                         | Outpatient Health | Office  | Service | Food sales | Retail  | Religious Worship | Restaurant | Public Assembly | Education |
|--------------------|----------------------------------------|-------------------|---------|---------|------------|---------|-------------------|------------|-----------------|-----------|
| Ductless Heat Pump | Demand reduction (kW/ft <sup>3</sup> ) | -0.0007           | -0.0005 | -0.0008 | -0.0002    | -0.0004 | -0.0003           | -0.0004    | -0.0002         | -0.0005   |

|                                               |                                          |         |         |         |         |         |         |         |         |         |
|-----------------------------------------------|------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| displacing Oil Heating                        | Electric Savings (kWh/ft <sup>4</sup> )  | -2.17   | -1.64   | -2.49   | -0.73   | -1.35   | -0.98   | -1.15   | -0.66   | -1.66   |
|                                               | Oil Savings (MMbtu/ft <sup>5</sup> )     | 0.029   | 0.022   | 0.033   | 0.010   | 0.019   | 0.013   | 0.015   | 0.009   | 0.022   |
| Ductless Heat Pump displacing Propane Heating | Demand reduction (kW/ft <sup>6</sup> )   | -0.0008 | -0.0006 | -0.0009 | -0.0003 | -0.0005 | -0.0004 | -0.0004 | -0.0002 | -0.0006 |
|                                               | Electric Savings (kWh/ft <sup>7</sup> )  | -3.74   | -2.84   | -4.30   | -1.25   | -2.33   | -1.82   | -1.98   | -1.14   | -2.87   |
|                                               | Propane Savings (MMbtu/ft <sup>8</sup> ) | 0.053   | 0.040   | 0.060   | 0.018   | 0.033   | 0.024   | 0.028   | 0.016   | 0.040   |

### Baseline Efficiency:

For propane the baseline is an existing inefficient furnace at 75% AFUE boiler.<sup>4</sup> For oil the baseline is an existing inefficient furnace at 75% AFUE boiler.<sup>5</sup>

Cooling baseline is a ducted A/C Blended Baseline that includes split AC (14 SEER), package AC (14 SEER), room AC (8 EER) and no AC.<sup>6</sup>

### High Efficiency:

The high efficiency case is a new 18 SEER/10 HSPF ductless minisplit heat pump.

### Measure Life:

The measure life is based on evaluation results.

| Measure Name                                      | Core Initiative | PA  | EUL <sup>7</sup> | OYF | RUL | AML |
|---------------------------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Ductless Heat Pump displacing Oil/Propane Heating | CI_EQUIP        | All | 17               | n/a | n/a | 17  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name | Core Initiative | PA | ISR | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|----|-----|-----------------|------------------|------------------|------------------|------------------|------------------|
|--------------|-----------------|----|-----|-----------------|------------------|------------------|------------------|------------------|------------------|

|                                               |          |     |      |      |      |      |      |       |      |
|-----------------------------------------------|----------|-----|------|------|------|------|------|-------|------|
| Ductless Heat Pump displacing Oil Heating     | CI_EQUIP | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.31 | 0.30 |
| Ductless Heat Pump displacing Propane Heating | CI_EQUIP | All | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | -0.27 | 0.30 |

**In-Service Rates:**

All installations have 100% in-service rates 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 calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>9</sup> |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Ductless Heat Pump displacing Oil/Propane Heating | CI_EQUIP        | All | 0.31 | 0.22            | 0.00             | 0.91             |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

**8** : Cadeo (2020). MA Energy Optimization C&I Study. [MA19C04-E-EO - Task 3 Methodology Memo FINAL 16JAN2020 clean](#)

**3** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**4** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**5** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**6** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**7** : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load [2018 Navigant HES Impact Evaluation](#)

**8** : Cadeo (2020). MA Energy Optimization C&I Study. [MA19C04-E-EO - Task 3 Methodology Memo FINAL 16JAN2020 clean](#)

**4** : Agreed upon value with EEAC consultants.

**5** : Department of Energy (2011). Federal Register / Vol. 76, No. 123 [http://www1.eere.energy.gov/buildings/appliance\\_standards/pdfs/cacfurn\\_dfr.pdf](http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf)

**6** : Navigant Consulting (2018). Baseline Study Saturation Result [2018 Navigant Baseline Loadshape Comprehensive Report](#)

**7** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**9** : Proxy as ME from MA20R28-B-RCDNTG

### 3.48. HVAC - Ductless Heat Pump, <5.4 Tons

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-XXY                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a high efficiency ductless minisplit or multisplit heat pump unit with cooling capacity less than 65 kBtu/h.

#### BCR Measure IDs:

| Measure Name                  | Core Initiative                            | BCR Measure ID |
|-------------------------------|--------------------------------------------|----------------|
| Ductless Heat Pump, <5.4 Tons | C&I New & Replacement Equipment (CL_EQUIP) | EC2b102        |

#### Algorithms for Calculating Primary Energy Impact:

For air cooled units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/h) * (1/SEER_{BASE} - 1/SEER_{EE}) * EFLH_{COOL}$$

$$\Delta kWh_{heat} = (kBtu/h) * (1/HSPF_{BASE} - 1/HSPF_{EE}) * EFLH_{HEAT}$$

$$\Delta kW_{cool} = (kBtu/h)_{Cool} * (1/EER_{BASE} - 1/EER_{EE})$$

#### Where:

SEER<sub>BASE</sub> = Seasonal Energy Efficiency Ratio of baseline HP equipment

SEER<sub>EE</sub> = Seasonal Energy Efficiency Ratio of new efficient HP equipment.

HSPF<sub>BASE</sub> = Heating Seasonal Performance Factor of baseline HP equipment

HSPF<sub>EE</sub> = Heating Seasonal Performance Factor of new efficient HP equipment.

EER<sub>BASE</sub> = Energy Efficiency Ratio of baseline HP equipment

EER<sub>EE</sub> = Energy Efficiency Ratio of new efficient HP equipment

EFLH<sub>COOL</sub> = Cooling mode equivalent full load hours. See notes and table for default values.

EFLH<sub>HEAT</sub> = Heating mode equivalent full load hours. See notes and table for default values.

Note: Average cooling EFLHs are from the 2010 NEEP HVAC Loadshape study.<sup>1</sup> PA derived from the NEEP results, weighted based on ISO-NE load zones for each PA. Average cooling hours and Capacity Adjustment Factors derived from the NEEP study to align with use of IEER.

### PA Specific Inputs

| PA      | EFLH <sub>cool</sub> | EFLH <sub>heat</sub> |
|---------|----------------------|----------------------|
| NGRID   | 935                  | 984                  |
| CLC     | 1,172                | 530                  |
| Unitil  | 755                  | 1,329                |
| ES West | 755                  | 1,329                |
| ES East | 1,172                | 530                  |

### Baseline Efficiency:

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by IECC 2018.

Heat Pump Baseline Efficiency Levels:<sup>2</sup>

| Equipment Type | Unit Type | Tier | Size Category          | Sub Category            | Full Load Cooling Efficiency |     | Seasonal/ Part Load Cooling Efficiency |     | Heating Efficiency |
|----------------|-----------|------|------------------------|-------------------------|------------------------------|-----|----------------------------------------|-----|--------------------|
| Air-Cooled     | AC or HP  | 1    | < 65 kBtuh (<5.4 Tons) | Split or Package System | 12.0 EER                     | and | 15.0 SEER                              | and | 9.0 HSPF           |
|                |           | 2    |                        |                         | 12.0 EER                     | and | 16.0 SEER                              | and | 9.0 HSPF           |
|                |           | 3    |                        |                         | 12.0 EER                     | and | 17.0 SEER                              | and | 9.0 HSPF           |

### High Efficiency:

The high efficiency case is a new 18 SEER/10 HSPF (single head non-ducted multi-split heat pump) or a new 16 SEER/9.5 HSPF (multi-head minisplit heat pump).

### Measure Life:

| Measure Name                  | Core Initiative | PA  | EUL <sup>3</sup> | OYF | RUL | AML |
|-------------------------------|-----------------|-----|------------------|-----|-----|-----|
| Ductless Heat Pump, <5.4 Tons | CI_EQUIP        | All | 17               | n/a | n/a | 17  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Ductless Heat Pump, <5.4 Tons | CI_EQUIP        | All | 1.00 | 1.00            | n/a              | n/a              | n/a              | 0.31             | 0.81             |

### In-Service Rates:

All installations have 100% in-service rates 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 <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>s</sup> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Ductless Heat Pump, <5.4 Tons | CI_EQUIP        | All | 0.25 | 0.00            | 0.09             | 0.84             |

### Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

### Endnotes:

1 : 2020 NEEP Loadshape Study -

[https://neep.org/sites/default/files/resources/NEEP\\_HVAC\\_Load\\_Shape\\_Report\\_Final\\_August2\\_0.pdf](https://neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf)

2 : IECC 2018 International Energy Code

3 : Measure life Air source heat Pump GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.

GDS\_2007\_Measure\_Life\_Report\_Residential\_and\_CI\_Lighting\_and\_HVAC\_Measures

8 : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.

[2021 NMR C&I Omnibus NTG](#)



### 3.49. HVAC - Energy Management System

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-EMS                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

The measure is the installation of a new building energy management system (EMS) or the expansion of an existing energy management system for control of non-lighting electric and gas end-uses in an existing building on existing equipment.

#### BCR Measure IDs:

| Measure Name                       | Core Initiative                           | BCR Measure ID |
|------------------------------------|-------------------------------------------|----------------|
| Energy Management System           | C&I Existing Building Retrofit (CI_RETRO) | EC2a006        |
| Energy Management System (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a045        |

#### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings for energy management systems (EMS) are custom calculated using the PA's EMS savings calculation tools. These tools are used to calculate energy and demand savings based on project-specific details including hours of operation, HVAC system equipment, and efficiency and points controlled.<sup>1</sup>

| Measure Name             | Energy Type | MMbtu/kWh |
|--------------------------|-------------|-----------|
| Energy Management System | Gas         | 0.001277  |
| Energy Management System | Oil         | 0.002496  |

#### Baseline Efficiency:

The baseline for this measure assumes the relevant HVAC equipment has no control.

#### High Efficiency:

The high efficiency case is the installation of a new EMS or the expansion of an existing EMS to control additional non-lighting electric or gas equipment. The EMS must be installed in an existing building on existing equipment.

**Measure Life:**

For retrofit applications, the measure life is 10 years.<sup>2</sup>

| Measure Name             | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------|-----------------|-----|-----|-----|-----|-----|
| Energy Management System | CI_RETRO        | All | 10  | n/a | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                       | Core Initiative | PA                  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------|-----------------|---------------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Energy Management System           | CI_RETRO        | National Grid       | 1.00 | 1.04            | 1.04             | 1.03             | 1.03             | custom           | custom           |
| Energy Management System           | CI_RETRO        | Eversource          | 1.00 | 1.01            | 1.01             | 1.09             | 1.57             | 0.82             | 0.05             |
| Energy Management System           | CI_RETRO        | Unitil              | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.82             | 0.05             |
| Energy Management System           | CI_RETRO        | CLC                 | 1.00 | 1.01            | 1.01             | 1.09             | 1.57             | 0.82             | 0.05             |
| Energy Management System (Turnkey) | CI_RETRO        | Eversource / Unitil | 1.00 | 0.946           | n/a              | 1.265            | 1.415            | 1.00             | 1.00             |
| Energy Management System (Turnkey) | CI_RETRO        | National Grid / CLC | 1.00 | 1.049           | n/a              | 0.941            | 1.174            | 1.00             | 1.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

- National Grid RRs derived from a 1994 study of HVAC and process cooling equipment<sup>3</sup>
- Eversource, CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations<sup>4</sup>
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- Energy and Demand RRs for Turnkey installations are based on the Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures study.<sup>5</sup>

**Coincidence Factors:**

- National Grid: CFs are custom calculated.
- Eversource, CLC, Unitol: on-peak CFs based on standard assumptions.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

Impact factors from 2021 C&I NTG evaluation.

| Measure Name                       | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Energy Management System           | CI_RETRO        | All | 4.6% | 1.3%            | 5.3%             | 102% |
| Energy Management System (turnkey) | CI_RETRO        | All | 7.7% | 1.3%            | 0.4%             | 94%  |

**Non-Energy Impacts:**

Impact factors from 2012 C&I NEI evaluation.

| Measure Name                       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Energy Management System           | CI_RETR<br>O    | All |                    |                      | \$0.156           |                     |                     |                       |
| Energy Management System (turnkey) | CI_RETR<br>O    | All |                    |                      | \$0.222           |                     |                     |                       |

**Endnotes:**

**1** : Descriptions of the EMS savings calculation tools are included in the TRM Library “C&I Spreadsheet Tools” folder.

**2** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1. [ERS 2005 Measure Life Study](#)

**3** : The Fleming Group (1994). Persistence of Commercial/Industrial Non-Lighting Measures, Volume 3, Energy Management Control Systems. Prepared for New England Power Service Company [Fleming Group 1994 Persistence of Commercial Industrial Non Lighting Measures Volume 3 Energy Management Control Systems](#)

**4** : RLW Analytics (2008). Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report. Prepared for NSTAR Electric and Gas; Table 17

[RLW 2008 Business and Construction Solutions Programs Measurement and Verification 2006 Final Report](#)

**5** : DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.

**6** : MA Common Assumption

### 3.50. HVAC - Furnace, Gas

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-F                               |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

The installation of a high efficiency natural gas warm air furnace with an electronically commutated motor (ECM) for the fan. High efficiency furnaces are better at converting fuel into direct heat and better insulated to reduce heat loss. ECM fan motors significantly reduce fan motor electric consumption as compared to both shaped-pole and permanent split capacitor motors.

#### BCR Measure IDs:

| Measure Name                          | Core Initiative                            | BCR Measure ID |
|---------------------------------------|--------------------------------------------|----------------|
| Heating System, Furnace, Gas 95% Muni | C&I New & Replacement Equipment (CI_EQUIP) | GC2b008        |
| Heating System, Furnace, Gas 97% Muni | C&I New & Replacement Equipment (CI_EQUIP) | GC2b010        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name | $\Delta$ MMBtu | $\Delta$ kWh <sup>2</sup> | $\Delta$ kW |
|--------------|----------------|---------------------------|-------------|
| Furnace, 95% | 6.7            | 168                       | 0.124       |
| Furnace, 97% | 7.7            | 168                       | 0.124       |

#### Baseline Efficiency:

The baseline efficiency in an 85% AFUE furnace.

#### High Efficiency:

The high efficiency scenario assumes either a gas-fired furnace equal or higher than 95% AFUE or 97% AFUE.

**Measure Life:**

The measure life is 18 years.<sup>2</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Furnaces     | CI_EQUIP        | All | 18  | n/a | n/a | 18  |

**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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Furnaces     | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | 0.00             | 0.16             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate.

**Coincidence Factors:**

Values pertain to other resource impacts for the EC motors.

**Impact Factors for Calculating Net Savings:**

Values are based on an evaluation study.<sup>3</sup>

| Measure Name | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------|-----------------|-----|-------|-----------------|------------------|-------|
| Furnaces     | CI_EQUIP        | All | 37.3% | 2.6%            | 19.1%            | 84.4% |

**Non-Energy Impacts:**

Impact factors are deemed from the study results.<sup>4</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Furnaces     | CI_EQUIP        | All |                    |                      |                   |                     | \$ 2.80             |                       |

**Endnotes:**

**2 :** ERS (2011) Pilot Evaluation of BFM DRAFT. Results as of 9/29/2011. The savings values for the BFM come from Page 1, Table 1 of the BFM impact evaluation filed with the Annual Report. While this report was only to provide savings for the BFM - -the original savings used by the PA's 600 kWh and

.116 kW were used for both the BFM and ECM. When the BFM study was almost complete we asked the evaluation team if it were possible to come up with savings for the ECM motor; they calculated the 168 kWh using data from the BFM onsites, after several discussions the evaluation team determined the ECM motor was a different measure than the BFM so the calculations were not 100% accurate. They note that while the 600 kWh was too high, the 168 may be on the low side but could not confirm without an evaluation of the ECM. PA's determined while we did not have an evaluation for the 168 it was probably a more realistic number than the 600.

**2** : ASHRAE Applications Handbook (2003); Page 36.3

**3** : NMR Group, Inc. (2018). Massachusetts Sponsor's Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

**4** : DNVGL (2016). Commercial and Industrial New Construction Non-Energy Impacts Study  
[DNVGL 2016 CI NC NEI](#)

### 3.51. HVAC - Heat Pump - C&I Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-HP-C                            |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

**Measure Description:**

Installation of a custom heat pump to displace electric heat.

**BCR Measure IDs:**

| Measure Name                                                       | Core Initiative                           | BCR Measure ID |
|--------------------------------------------------------------------|-------------------------------------------|----------------|
| Custom - Heat Pumps displacing Electric Heat (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a108        |

**Algorithms for Calculating Primary Energy Impact:**

Savings will be calculated by the vendor based on existing site conditions.

**Baseline Efficiency:**

The baseline efficiency case is the existing site conditions.

**High Efficiency:**

The high efficiency case will vary by site.

**Measure Life:**

The measure life will vary depending on the type of equipment installed.

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                      | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Custom Heat Pumps, Displacing Electric Heat (Residential End Use) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |

**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% because the measure is new and has not been evaluated.

**Coincidence Factors:**

Coincidence factors for replacing electric baseboard come from the Demand Impact Model.<sup>1</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross rates are set to 100% because the measure is new and has not been evaluated.

| Measure Name                                                      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Custom Heat Pumps, Displacing Electric Heat (Residential End Use) | CI_RETRO        | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.<sup>2</sup>

| Measure Name                                                      | Core Initiative | PA        | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------------------------------|-----------------|-----------|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Custom Heat Pumps, Displacing Electric Heat (Residential End Use) | CI_RETRO        | Statewide |                    |                      | \$0.05            |                     |                     |                       |

**Endnotes:**

1 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)

2 : NMR Group, Inc. (2021). C&I O&M and Non-O&M Non-Energy Impacts Study [2021 NMR CIOM and NonOM NEI Study](#)



### 3.52. HVAC - Heat Pump - Electrification

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-FS                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Lost Opportunity                         |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a ducted or ductless heat pump system to replace baseline fuel (oil/propane/gas) heating system.

#### BCR Measure IDs:

| Measure                                      | Core Initiative                            | BCR Measure ID |
|----------------------------------------------|--------------------------------------------|----------------|
| Ducted Heat Pump replacing Oil Heating       | C&I New & Replacement Equipment (CI_EQUIP) | EC2b115        |
| Ductless Heat Pump replacing Oil Heating     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b116        |
| Ducted Heat Pump replacing Propane Heating   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b117        |
| Ductless Heat Pump replacing Propane Heating | C&I New & Replacement Equipment (CI_EQUIP) | EC2b118        |
| Ducted Heat Pump displacing Gas Heating      | C&I New & Replacement Equipment (CI_EQUIP) | GC2b052        |
| Ductless Heat Pump displacing Gas Heating    | C&I New & Replacement Equipment (CI_EQUIP) | GC2b053        |
| Ducted Heat Pump replacing Gas Heating       | C&I New & Replacement Equipment (CI_EQUIP) | GC2b054        |
| Ductless Heat Pump replacing Gas Heating     | C&I New & Replacement Equipment (CI_EQUIP) | GC2b055        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a model<sup>1</sup> developed to estimate the savings associated with the displacement of existing heating (and cooling) systems by CBECS building type. Methods and algorithms are currently under review.

### Baseline Efficiency:

For propane the baseline is an existing inefficient furnace at 82% AFUE. For oil the baseline is an existing inefficient furnace at 84% AFUE boiler. For gas the baseline is an existing inefficient furnace at 85% AFUE.

Cooling baseline is a ducted A/C Blended Baseline that includes split AC (14 SEER), package AC (14 SEER), room AC (8 EER) and no AC.

Baselines determined by model<sup>2</sup> used to develop savings estimates.

### High Efficiency:

The high efficiency case is 17 SEER/9.0 HSPF for ducted systems and 23 SEER/11.5 HSPF for ductless systems.

### Measure Life:

| Measure Name                                     | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| C&I Ducted/ductless HP replacing/displacing fuel | CI_EQUIP        | All | 17  | n/a | n/a | 17  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                 | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> <sup>3</sup> | CF <sub>WP</sub> |
|----------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|-------------------------------|------------------|
| Ducted Heat Pump replacing Oil Heating       | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.22                         | 0.30             |
| Ductless Heat Pump replacing Oil Heating     | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.31                         | 0.30             |
| Ducted Heat Pump replacing Propane Heating   | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.17                         | 0.30             |
| Ductless Heat Pump replacing Propane Heating | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.27                         | 0.30             |
| Ducted Heat Pump displacing Gas Heating      | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.17                         | 0.30             |
| Ductless Heat Pump displacing Gas Heating    | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.27                         | 0.30             |
| Ducted Heat Pump replacing Gas Heating       | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.17                         | 0.30             |

| Measure Name                             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> <sup>3</sup> | CF <sub>WP</sub> |
|------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|-------------------------------|------------------|
| Ductless Heat Pump replacing Gas Heating | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | -0.27                         | 0.30             |

**In-Service Rates:**

All installations have 100% in-service rates since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are assumed 100% until evaluated.

**Coincidence Factors:**

Coincidence factors are calculated to reflect blend of heating and cooling.

**Impact Factors for Calculating Net Savings:**

| Measure Name                                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG <sup>4</sup> |
|----------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|
| Ducted Heat Pump replacing Oil Heating       | CI_EQUIP        | All | 0.31 | 0.22            | 0.00             | 0.84             |
| Ductless Heat Pump replacing Oil Heating     | CI_EQUIP        | All | 0.31 | 0.22            | 0.00             | 0.84             |
| Ducted Heat Pump replacing Propane Heating   | CI_EQUIP        | All | 0.31 | 0.22            | 0.00             | 0.84             |
| Ductless Heat Pump replacing Propane Heating | CI_EQUIP        | All | 0.31 | 0.22            | 0.00             | 0.84             |
| Ducted Heat Pump displacing Gas Heating      | CI_EQUIP        | All | 0.17 | 0.05            | 0.00             | 0.88             |
| Ductless Heat Pump displacing Gas Heating    | CI_EQUIP        | All | 0.17 | 0.05            | 0.00             | 0.88             |
| Ducted Heat Pump replacing Gas Heating       | CI_EQUIP        | All | 0.17 | 0.05            | 0.00             | 0.88             |
| Ductless Heat Pump replacing Gas Heating     | CI_EQUIP        | All | 0.17 | 0.05            | 0.00             | 0.88             |

**Non-Energy Impacts:**

NEIs are based on study results.<sup>5</sup>

| Measure Name                                     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| C&I Ducted/ductless HP replacing/displacing fuel | CI_EQUIP        | All |                    |                      | \$0.05            |                     |                     |                       |

**Endnotes:**

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- 1 : [MA19C04-E-EO - MA Energy Optimization Model 19APR2021](#)
- 2 : [MA19C04-E-EO - MA Energy Optimization Model 19APR2021](#)
- 3 : Applied from small C&I (
- 4 : NMR Group Inc. (2021). C&I Prescriptive and Custom Omnibus Net-to-Gross Study.  
[2021 NMR C&I Omnibus NTG](#)
- 5 : MA20X10-B-CIOMNEI

### 3.53. HVAC - Heat Pump System

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-HPS                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Replace on Burnout                       |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

This measure applies to the installation of high-efficiency heat pumps used for space cooling in C&I applications. This includes air cooled, water source, ground water source, ground source, variable refrigerant flow, and mini-split heat pumps.

#### BCR Measure IDs:

| Measure Name                               | Core Initiative                            | BCR Measure ID |
|--------------------------------------------|--------------------------------------------|----------------|
| Midstream - Heat Pump Systems              | C&I New & Replacement Equipment (CI_EQUIP) | EC2b052        |
| Midstream - Water Source Heat Pump Systems | C&I New & Replacement Equipment (CI_EQUIP) | EC2b064        |
| Midstream - DMSHP Systems                  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b053        |
| Midstream - VRF                            | C&I New & Replacement Equipment (CI_EQUIP) | EC2b087        |

#### Algorithms for Calculating Primary Energy Impact:

For air cooled units with cooling capacities less than 65 kBtu/h, including mini-split heat pumps:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/h) * (1/SEER_{BASE} - 1/SEER_{EE}) * EFLH_{COOL}$$

$$\Delta kWh_{heat} = (kBtu/h) * (1/HSPF_{BASE} - 1/HSPF_{EE}) * EFLH_{HEAT}$$

$$\Delta kW_{cool} = (kBtu/h)_{Cool} * (1/EER_{BASE} - 1/EER_{EE})$$

For all water source, groundwater source, and ground source units. Also for air cooled units with cooling capacities equal to or greater than 65 kBtu/h and EER available:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/h_{Cool}) * (1/EER_{BASE} - 1/EER_{EE}) * EFLH_{COOL}$$

$$\Delta kWh_{heat} = (kBtu/h_{heat})/3.412 * (1/COP_{BASE} - 1/COP_{EE}) * EFLH_{HEAT}$$

$$\Delta kW_{cool} = (kBtu/h)_{Cool} * (1/EER_{BASE} - 1/EER_{EE})$$

For air cooled units with cooling capacities equal to or greater than 65 kBtu/h with available IEER:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/h_{cool}) * (1/IEER_{BASE} - 1/IEER_{EE}) * (Hours_{COOL}) (Cap_{adj})$$

$$\Delta kWh_{heat} = (kBtu/h_{heat})/3.412 * (1/COP_{BASE} - 1/COP_{EE}) * EFLH_{HEAT}$$

$$\Delta kW_{cool} = (kBtu/h)_{Cool} * (1/EER_{BASE} - 1/EER_{EE})$$

Where:

$\Delta kWh_{COOL}$  = Gross annual cooling mode kWh savings from the measure.

$\Delta kWh_{HEAT}$  = Gross annual heating mode kWh savings from the measure.

$\Delta kW_{COOL}$  = Gross annual kW savings from the measure. Heating kW savings are negligible.

$kBtu/h^1$  = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).

$SEER_{BASE}$  = Seasonal Energy Efficiency Ratio of the baseline equipment. See Baseline Efficiency section for values.

$SEER_{EE}$  = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

$EFLH_{COOL}$  = Cooling mode equivalent full load hours. See notes and table for default values.

$HSPF_{BASE}$  = Heating Seasonal Performance Factor of the baseline equipment. See Baseline Efficiency section for values.

$HSPF_{EE}$  = Heating Seasonal Performance Factor of the energy efficient equipment.

$EFLH_{HEAT}$  = Heating mode equivalent full load hours. See notes and table for default values.

$kBtu/h_{COOL}$  = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equal 12 kBtu/h).

$EER_{BASE}$  = Energy Efficiency Ratio of the baseline equipment. See Baseline Efficiency section for values.

$EER_{EE}$  = Energy Efficiency Ratio of the energy efficient equipment.

$kBtu/h_{HEAT}$  = Capacity of the heating equipment in kBtu per hour. If the heating capacity is unknown, it can be calculated from the cooling capacity<sup>2</sup>

3.412 = Conversion factor: 3.412 Btu per Wh.

$COP_{BASE}$  = Coefficient of performance of the baseline equipment. See Baseline Efficiency section for values.

$COP_{EE}$  = Coefficient of performance of the energy efficient equipment.

$IEER_{BASE}$  = Integrated Energy Efficiency Ratio of the baseline equipment. See Baseline Efficiency section for values.

$IEER_{EE}$  = Integrated Energy Efficiency Ratio of the energy efficient equipment.

$Hours_{Cool}$  = Annual Cooling Hours. See notes and table below for default values.

$Cap_{adj}$  = Capacity Adjustment Factor:<sup>3</sup> See notes and table below for values.

Note: Average cooling EFLHs are from the 2010 NEEP HVAC Loadshape study.<sup>4</sup> PA derived from the NEEP results, weighted based on ISO-NE load zones for each PA. Average cooling hours and Capacity Adjustment Factors derived from the NEEP study to align with use of IEER.<sup>5</sup>

### PA Specific Inputs

| PA      | $EFLH_{cool}$ | $Hours_{cool}$ | $Cap_{adj}$ | $EFLH_{heat}$ |
|---------|---------------|----------------|-------------|---------------|
| NGRID   | 935           | 2,539          | 0.722       | 984           |
| CLC     | 1,172         | 3,027          | 0.681       | 530           |
| Unitil  | 755           | 1,896          | 0.733       | 1,329         |
| ES West | 755           | 1,896          | 0.733       | 1,329         |

|         |       |       |       |     |
|---------|-------|-------|-------|-----|
| ES East | 1,172 | 3,027 | 0.681 | 530 |
|---------|-------|-------|-------|-----|

**Baseline Efficiency:**

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by IECC 2015 for 2019. Baseline assumptions for 2020+ have yet to be finalized, but will likely be in accordance with IECC 2018 requirements.

Heat Pump Baseline Efficiency Levels:<sup>8</sup>

| Equipment Type | Unit Type | Tier | Size Category                                           | Sub Category                    | Full Load Cooling Efficiency |     | Seasonal/Part Load Cooling Efficiency |     | Heating Efficiency |
|----------------|-----------|------|---------------------------------------------------------|---------------------------------|------------------------------|-----|---------------------------------------|-----|--------------------|
| Air-Cooled     | AC or HP  | 1    | < 65 kBtuh (<5.4 Tons)                                  | Split or Package System         | 12.0 EER                     | and | 15.0 SEER                             | and | 9.0 HSPF           |
|                |           | 2    |                                                         |                                 | 12.0 EER                     | and | 16.0 SEER                             | and | 9.0 HSPF           |
|                |           | 3    |                                                         |                                 | 12.0 EER                     | and | 17.0 SEER                             | and | 9.0 HSPF           |
| Air-Cooled     | AC or HP  | 1    | ≥ 65 kBtuh and < 135 kBtuh (≥ 5.4 Tons and < 11.3 Tons) | Split System and Single Package | 12.0 EER                     | and | 13.1 IEER                             | and | 3.4 COP            |
|                |           | 2    |                                                         |                                 | 12.0 EER                     | and | 14.5 IEER                             | and | 3.4 COP            |
|                |           | 3    |                                                         |                                 | 12.0 EER                     | and | 18.0 IEER                             | and | 3.4 COP            |
| Air-Cooled     | AC or HP  | 1    | ≥ 135 kBtuh and < 240 kBtuh (≥ 11.3 Tons and < 20 Tons) | Split System and Single Package | 11.5 EER                     | and | 13.0 IEER                             | and | 3.2 COP            |
|                |           | 2    |                                                         |                                 | 11.5 EER                     | and | 14.0 IEER                             | and | 3.2 COP            |
|                |           | 3    |                                                         |                                 | 11.5 EER                     | and | 17.5 IEER                             | and | 3.2 COP            |
| Air-Cooled     | AC or HP  | 1    | ≥ 240 kBtuh and <760 kBtuh (≥ 20 Tons and < 63.3 Tons)  | Split System and Single Package | 10.1 EER                     | and | 12.0 IEER                             | and | 3.2 COP            |
|                |           | 2    |                                                         |                                 | 10.1 EER                     | and | 13.0 IEER                             | and | 3.2 COP            |
|                |           | 3    |                                                         |                                 | 10.1 EER                     | and | 14.0 IEER                             | and | 3.2 COP            |

|                                      |                              |   |                                                                      |                                 |          |     |           |     |          |
|--------------------------------------|------------------------------|---|----------------------------------------------------------------------|---------------------------------|----------|-----|-----------|-----|----------|
| Air-Cooled                           | AC or HP                     | 1 | $\geq 760$ kBtuh ( $\geq 63.3$ Tons)                                 | Split System and Single Package | 9.7 EER  | and | 13.0 IEER | and | 3.2 COP  |
|                                      |                              | 2 |                                                                      |                                 | 9.7 EER  | and | 14.0 IEER | and | 3.2 COP  |
|                                      |                              | 3 |                                                                      |                                 | 9.7 EER  | and | 16.0 IEER | and | 3.2 COP  |
| Water-Cooled                         | Water Source HP              | 1 | Any Size                                                             | Split System and Single Package | 14.0 EER |     | -         | and | 4.6 COP  |
|                                      |                              | 2 |                                                                      |                                 | 15.0 EER |     | -         | and | 4.6 COP  |
|                                      |                              | 3 |                                                                      |                                 | 16.0 EER |     | -         | and | 4.6 COP  |
| Water-Cooled                         | Ground Source Closed Loop HP | 1 | Any Size                                                             | Split System and Single Package | 15.0 EER |     | -         | and | 3.5 COP  |
| Water-Cooled                         | Ground Source Open Loop HP   | 1 | Any Size                                                             | Split System and Single Package | 19.0 EER |     | -         | and | 4.0 COP  |
| Water-Cooled or Evaporatively-Cooled | AC                           | 1 | $< 65$ kBtuh ( $< 5.4$ Tons)                                         | Split System and Single Package | 13.5 EER | and | 14.0 IEER |     | -        |
| Water-Cooled or Evaporatively-Cooled | AC                           | 1 | $\geq 65$ kBtuh and $< 240$ kBtuh ( $\geq 5.4$ Tons and $< 20$ Tons) | Split System and Single Package | 13.0 EER | and | 15.5 IEER |     | -        |
| Water-Cooled or Evaporatively-Cooled | AC                           | 1 | $\geq 240$ kBtuh ( $\geq 20$ Tons)                                   | Split System and Single Package | 12.5 EER | and | 14.5 IEER |     | -        |
| Air-Cooled                           |                              | 1 |                                                                      |                                 | 12.0 EER | and | 20 SEER   | and | 9.0 HSPF |



|              |                                      |   |                        |                                |          |     |         |     |           |
|--------------|--------------------------------------|---|------------------------|--------------------------------|----------|-----|---------|-----|-----------|
|              | AC or HP (Ductless Mini/Multi Split) | 2 | < 65 kBtuh (<5.4 Tons) | Ductless Mini and Multi Splits | 12.0 EER | and | 23 SEER | and | 11.5 HSPF |
| Air-Cooled   | HP (VRF)                             | 1 | ≥ 65 kBtuh (≥5.4 Tons) | VRF                            | 11.0 EER | and | 18 IEER | and | 3.4 COP   |
| Water-Cooled | HP (VRF)                             | 1 | ≥ 65 kBtuh (≥5.4 Tons) | VRF                            | 12.0 EER | and | 20 IEER | and | 4.3 COP   |

### High Efficiency:

The high efficiency case assumes the HVAC equipment meets or exceeds the Consortium for Energy Efficiency's (CEE) specification. This specification results in cost-effective energy savings by specifying higher efficiency HVAC equipment while ensuring that several manufacturers produce compliant equipment. The CEE specification is reviewed and updated annually to reflect changes to the ASHRAE and IECC energy code baseline as well as improvements in the HVAC equipment technology. Equipment efficiency is the rated efficiency of the installed equipment for each project.

### Measure Life:

The measure life is 17 years.<sup>9</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Heat Pump    | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name   | Core Initiative | PA             | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------|-----------------|----------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| All Heat Pumps | CI_EQUIP        | National Grid  | 1.00 | 1.05            | 1.05             | 1.00             | 1.00             | 0.40             | 0.00             |
| All Heat Pumps | CI_EQUIP        | Eversource CLC | 1.00 | 1.01            | 1.01             | 1.09             | 1.57             | 0.45             | 0.00             |

|                |          |        |      |      |      |      |      |      |      |
|----------------|----------|--------|------|------|------|------|------|------|------|
| All Heat Pumps | CI_EQUIP | Unitil | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.33 | 0.00 |
|----------------|----------|--------|------|------|------|------|------|------|------|

**In-Service Rates:**

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

**Realization Rates:**

- National Grid and energy and demand RRs based on a 1994 study of HVAC and process cooling equipment<sup>10</sup>
- Eversource and CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations<sup>11</sup>
- Unitil realization rates same as Unitary AC.

**Coincidence Factors:**

CFs based 2011 NEEP C&I Unitary HVAC Loadshape Project.<sup>12</sup>

**Impact Factors for Calculating Net Savings:**

Upstream Heat Pumps are based on a HVAC Upstream study which developed statewide net-to-gross results.<sup>13</sup>

| Measure Name                                          | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| HVAC Upstream - Heat Pump Systems 2019                | CI_EQUIP        | All | 45.0% | 0.0%            | 0.0%             | 55.0% |
| HVAC Upstream - Heat Pump Systems 2020                | CI_EQUIP        | All | 46.0% | 0.0%            | 0.0%             | 54.0% |
| HVAC Upstream - Heat Pump Systems 2021                | CI_EQUIP        | All | 47.0% | 0.0%            | 0.0%             | 53.0% |
| HVAC Upstream - Water Source Heat Pump Systems - 2019 | CI_EQUIP        | All | 50.0% | 0.0%            | 0.0%             | 50.0% |
| HVAC Upstream - Water Source Heat Pump Systems - 2020 | CI_EQUIP        | All | 51.0% | 0.0%            | 0.0%             | 49.0% |
| HVAC Upstream - Water Source Heat Pump Systems - 2021 | CI_EQUIP        | All | 52.0% | 0.0%            | 0.0%             | 48.0% |
| HVAC Upstream - Mini Split Heat Pump Systems - 2019   | CI_EQUIP        | All | 49.0% | 0.0%            | 0.0%             | 51.0% |
| HVAC Upstream - Mini Split Heat Pump Systems - 2020   | CI_EQUIP        | All | 51.0% | 0.0%            | 0.0%             | 49.0% |
| HVAC Upstream - Mini Split Heat Pump Systems - 2021   | CI_EQUIP        | All | 53.0% | 0.0%            | 0.0%             | 47.0% |
| HVAC Upstream - VRF - 2019                            | CI_EQUIP        | All | 45.0% | 0.0%            | 0.0%             | 55.0% |

|                            |          |     |       |      |      |       |
|----------------------------|----------|-----|-------|------|------|-------|
| HVAC Upstream - VRF - 2020 | CI_EQUIP | All | 46.0% | 0.0% | 0.0% | 54.0% |
| HVAC Upstream - VRF - 2021 | CI_EQUIP | All | 47.0% | 0.0% | 0.0% | 53.0% |

### Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

### Endnotes:

**1** : For equipment with cooling capacities less than 65 kBtu/h, it is assumed that the heating capacity and cooling capacity are equal.

**2** : For Air Source HPs: Heating Capacity = Cooling Capacity \* 13,900/12,000 (ratio of heat produced in heating mode to cooling produced in cooling mode). For Water/Ground Source HPs: Heating Capacity = Cooling Capacity \* COP/EER (converts the rated cooling output to the rated heating output).

**3** : The capacity adjustment factor is used only when IEER is used to determine energy savings. Since IEER takes into account performance at different loading points, the capacity adjustment factor helps to account for the fact that more load occurs at lower temperatures and capacities. The adjustment factor is greater than 1 for climate zones with lower full load hours and runtime, and the factor is less than 1 for zones with more full load hours and runtime.

**4** : KEMA (2011). C&I Unitary AC Loadshape Project - Final Report.

[KEMA 2011 CIUnitaryHVACLoadShapeProject](#)

**5** : DNV GL (2014). Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study. Capacity Factors are weighted using information about PA specific load zones.

[DNVGL 2014 Memo Modified Hours NEEP HVAC Loadshape Study](#)

**8** : Since IECC 2015 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

**9** : DNV GL (2018). Expected Useful Life (EUL) Estimation for Air-Conditioning Equipment from Current Age Distribution Memo. [2018 DNVGL P73 EUL Estimation Results to Date](#)

**10** : The Fleming Group (1994). Persistence of Commercial/Industrial Non-Lighting Measures, Volume 2, Energy Efficient HVAC and Process Cooling Equipment.

[Fleming Group 1994 Persistence of Commercial Industrial Non Lighting Measures Volume 2 Energy Efficiency HVAC and Process](#)

**11** : RLW Analytics (2008). Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report. Prepared for NSTAR Electric and Gas; Table 17.

[RLW 2008 Business and Construction Solutions Programs Measurement and Verification 2006 Final Report](#)

**12** : KEMA (2011). C&I Unitary HVAC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum. [KEMA 2011 CIUnitaryHVACLoadShapeProject](#)

**13** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.54. HVAC - High Efficiency Chiller

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-HEC                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

This measure promotes the installation of efficient water-cooled and air-cooled water chilling packages for comfort cooling applications. Eligible chillers include air-cooled, water cooled rotary screw and scroll, and water cooled centrifugal chillers for single chiller systems or for the lead chiller only in multi-chiller systems.

#### BCR Measure IDs:

| Measure Name                    | Core Initiative                                  | BCR Measure ID |
|---------------------------------|--------------------------------------------------|----------------|
| High Efficiency Chiller -- IPLV | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a011        |
| High Efficiency Chiller -- FL   | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a012        |
| High Efficiency Chiller -- IPLV | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b010        |
| High Efficiency Chiller -- FL   | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b011        |

#### Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings for chiller installations may be custom calculated using the PA's chillers savings calculation tool as is the case for Eversource who uses their own tool to custom calculate savings. These tools are used to calculate energy and demand savings based on site-specific chiller plant details including specific chiller plan equipment, operational staging, operating load profile and load profile.

Alternatively, the energy and demand savings may be calculated using the following algorithms and inputs. Please note that consistent efficiency types (FL or IPLV) must be used between the baseline and high efficiency cases. It is recommended that IPLV be used over FL efficiency types when possible.

#### Air-Cooled Chillers:

$$\text{kWh} = \text{Tons} * (12/\text{EER}_{\text{base}} - 12/\text{EER}_{\text{ee}}) * \text{Hours}$$

$$\text{kW} = \text{Tons} * (12/\text{EER}_{\text{base}} - 12/\text{EER}_{\text{ee}})$$

#### Water-Cooled Chillers:

$$\text{kWh} = \text{Tons} * (\text{kWtonbase} - \text{kWtonee}) * \text{Hours}$$

$$\text{kW} = \text{Tons} * (\text{kWtonbase} - \text{kWtonee}) * (\text{LF}/100)$$

Where:

Tons = Rated capacity of the cooling equipment

EERBASE = Energy Efficiency Ratio of the baseline equipment. See table below for values.

EEREE = Energy Efficiency Ratio of the efficient equipment. Site-specific.

kW/tonBASE = Energy efficiency rating of the baseline equipment. See table below for values.

kW/tonEE = Energy efficiency rating of the efficient equipment. Site-specific.

Hours = Equivalent full load hours for chiller operation

### Baseline Efficiency:

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in Chapter 13 of the aforementioned document, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2015.

The table below details the specific efficiency requirements by equipment type and capacity.

Chiller - Minimum Efficiency Requirements<sup>1</sup> :

| Equipment Type                                            | Size Category (Tons) | Units       | Path A    | Path A | Path B    | Path B |
|-----------------------------------------------------------|----------------------|-------------|-----------|--------|-----------|--------|
|                                                           |                      |             | Full Load | IPLV   | Full Load | IPLV   |
| Air-cooled chillers                                       | <150                 | EER (Btu/W) | 10.403    | 14.111 | 9.991     | 16.274 |
| Air-cooled chillers                                       | ≥150                 | EER (Btu/W) | 10.403    | 14.420 | 9.991     | 16.583 |
| Water cooled, electrically operated positive displacement | <75                  | kW/ton      | 0.728     | 0.582  | 0.757     | 0.485  |
| Water cooled, electrically operated positive displacement | ≥75 and <150         | kW/ton      | 0.698     | 0.543  | 0.728     | 0.475  |
| Water cooled, electrically operated positive displacement | ≥150 and <300        | kW/ton      | 0.640     | 0.524  | 0.660     | 0.427  |
| Water cooled, electrically operated positive displacement | ≥300 and <600        | kW/ton      | 0.592     | 0.504  | 0.606     | 0.398  |
| Water cooled, electrically operated positive displacement | ≥600                 | kW/ton      | 0.543     | 0.485  | 0.567     | 0.369  |
| Water cooled, electrically operated centrifugal           | <150                 | kW/ton      | 0.592     | 0.534  | 0.674     | 0.427  |

|                                                 |               |        |       |       |       |       |
|-------------------------------------------------|---------------|--------|-------|-------|-------|-------|
| Water cooled, electrically operated centrifugal | ≥150 and <300 | kW/ton | 0.592 | 0.534 | 0.616 | 0.388 |
| Water cooled, electrically operated centrifugal | ≥300 and <400 | kW/ton | 0.543 | 0.504 | 0.577 | 0.378 |
| Water cooled, electrically operated centrifugal | ≥400 and <600 | kW/ton | 0.543 | 0.485 | 0.567 | 0.369 |
| Water cooled, electrically operated centrifugal | ≥600          | kW/ton | 0.543 | 0.485 | 0.567 | 0.369 |

Note: Compliance with this standard may be obtained by meeting the minimum requirements of Path A or B, however, both the Full Load and IPLV must be met to fulfill the requirements of Path A or B.

### High Efficiency:

The high efficiency scenario assumes water chilling packages that exceed the efficiency levels required by Massachusetts State Building Code and meet the minimum efficiency requirements as stated in the New Construction HVAC energy efficiency rebate forms.

### Measure Life:

The measure life is 23 years.<sup>2</sup>

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure              | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Chillers – IPLV used | CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.49             | 0.06             |
| Chillers – FL used   | CI_NB&MR<br>CI_EQUIP | All | 1.00 | 2.63            | 2.63             | 1.00             | 1.00             | 0.86             | 0.10             |

### In-Service Rates:

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

### Realization Rates:

- RRs based on statewide prospective results from 2015 prescriptive chiller study<sup>3</sup>. Realization rates assume PA use of the prescriptive algorithms detailed above.

**Coincidence Factors:**

- CFs based on prospective statewide results from 2015 prescriptive chiller study<sup>4</sup>. Coincidence factors assume PA use of the prescriptive algorithms detailed above.

**Impact Factors for Calculating Net Savings:**

All PAs use Statewide net-to-gross results<sup>5</sup>. Net savings factors for CI\_NB&MR initiative are based on 2021 NRNC Study (paths 3&4)<sup>6</sup>. Net savings factors for CI\_EQUIP initiative are based on 2021 Omnibus NTG Study (prescriptive).

| Measure Name                   | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| High Efficiency Chiller - IPLV | CI_NB&MR        | All | 0.583 | 0.227           |                  | 0.644 |
| High Efficiency Chiller - FL   | CI_NB&MR        | All | 0.583 | 0.227           |                  | 0.644 |
| High Efficiency Chiller - IPLV | CI_EQUIP        | All | 0.25  | 0.002           | 0.085            | 0.84  |
| High Efficiency Chiller - FL   | CI_EQUIP        | All | 0.25  | 0.002           | 0.085            | 0.84  |

**Non-Energy Impacts:**

| Measure Name                   | Core Initiative    | PA  | Annual \$ per kWh | Annual \$ per Therm |
|--------------------------------|--------------------|-----|-------------------|---------------------|
| High Efficiency Chiller - IPLV | CI_NB&MR, CI_EQUIP | All | \$0.135           |                     |
| High Efficiency Chiller - FL   | CI_NB&MR, CI_EQUIP | All | \$0.135           |                     |

**Endnotes:**

- 1** : Energy Solutions (2018) Northeast Chillers Market Research.  
**2** : GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.  
[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)  
**3** : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. [DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)  
**4** : DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. [DNVGL 2015 Impact Eval Prescriptive Chiller CAIR FINAL](#)  
**5** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)  
**6** : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)

### 3.55. HVAC - High-Efficiency Condensing Unit

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-HECU                            |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Upstream high efficiency condensing unit (HECU) captures the savings attributed to an upstream commercial refrigeration condensing unit. Applicable to condensing units serving Low (0°F) and Medium (32°F) conditioned environments, an efficient condensing unit is defined by units incorporating three requisite attributes: an efficient scroll compressor, floating head pressure controls, and modulating compressor fan speed capabilities (for analysis purposes low/high speed capabilities are assumed, however some units are equipped with variable speed drives that would realize additional savings). The collective effect of these three features results in the refrigeration load requirements being met while using less power as compared to the baseline unit. Units with compressor horsepower ratings in the range of 1-5hp are eligible to participate in the upstream initiative. Eligibility is limited to outdoor units. Savings claimed assume the efficient unit replaces a baseline outdoor unit, however it's worth noting that a customer replacing an indoor unit with an outdoor unit would likely realize additional savings.

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                            | BCR Measure ID |
|---------------------------------------------|--------------------------------------------|----------------|
| Midstream - High-Efficiency Condensing Unit | C&I New & Replacement Equipment (CI_EQUIP) | EC2b095        |

#### Algorithms for Calculating Primary Energy Impact:

For the upstream HECU measure, prescriptive deemed savings are claimed based on a unit's temperature application, power phase requirements and compressor horsepower rating. For the purposes of the TRM, horsepower ratings are specified in 1/2 horsepower increments. In the event a qualifying unit falls somewhere in the middle of an established category, it will be assigned to the closest category with the most conservative total kWh savings.

#### HECU Electric Demand Savings

The tabulated energy savings values for each of the three components of the HECU (scroll compressor, compressor fans, floating head pressure controls) were divided by their respective annual full load operation hours, as described in the following table:



| Component                       | Annual Full Operating Hours                 | Source                                               |
|---------------------------------|---------------------------------------------|------------------------------------------------------|
| Scroll Compressor               | 2913 (w/ Economizer), 3910 (w/o Economizer) | EVT Refrigeration Analysis Tool (CATInput worksheet) |
| Compressor Fan(s)               | 6087                                        | As derived in HECU Compressor Fan Loadshape F        |
| Floating Head Pressure Controls | 7221                                        | EVT Refrigeration Analysis Tool (CATInput worksheet) |

The resulting connected load savings is shown in the following table. Units are in kW. For the purposes of coincident peak demand savings claims, the savings for each component will be treated separately against its respective loadshape, as described in the load shape section.

| Temp   | Phase | HP  | Scroll Compressor | Condenser Fan(s) | Floating Head Pressure Controls | Total   |
|--------|-------|-----|-------------------|------------------|---------------------------------|---------|
| Medium | 1     | 1   | 0.21997           | 0.07605          | 0.12982                         | 0.42585 |
|        |       | 1.5 | 0.16477           | 0.08149          | 0.15421                         | 0.40047 |
|        |       | 2   | 0.19216           | 0.09504          | 0.17984                         | 0.46704 |
|        |       | 2.5 | 0.22508           | 0.11132          | 0.21065                         | 0.54705 |
|        |       | 3   | 0.21755           | 0.14153          | 0.28241                         | 0.64149 |
|        |       | 3.5 | 0.30964           | 0.16165          | 0.30956                         | 0.78086 |
|        |       | 4   | 0.34246           | 0.17879          | 0.34237                         | 0.86362 |
|        |       | 4.5 | 0.34856           | 0.18197          | 0.34847                         | 0.87901 |
|        |       | 5   | 0.22508           | 0.18197          | 0.38505                         | 0.82928 |
|        | 3     | 1   | 0.15623           | 0.06806          | 0.11695                         | 0.34125 |
|        |       | 1.5 | 0.13245           | 0.07799          | 0.14330                         | 0.35374 |

|     |   |     |         |         |         |         |
|-----|---|-----|---------|---------|---------|---------|
|     |   | 2   | 0.15447 | 0.09095 | 0.16712 | 0.41255 |
|     |   | 2.5 | 0.18093 | 0.10654 | 0.19576 | 0.48323 |
|     |   | 3   | 0.18620 | 0.13028 | 0.24637 | 0.56284 |
|     |   | 3.5 | 0.27717 | 0.14907 | 0.26912 | 0.69535 |
|     |   | 4   | 0.30654 | 0.16487 | 0.29764 | 0.76905 |
|     |   | 4.5 | 0.31200 | 0.16780 | 0.30294 | 0.78275 |
|     |   | 5   | 0.27084 | 0.18512 | 0.34883 | 0.80478 |
| Low | 1 | 2   | 0.12604 | 0.09116 | 0.16728 | 0.38449 |
|     |   | 2.5 | 0.11317 | 0.10645 | 0.20257 | 0.42219 |
|     |   | 3   | 0.12627 | 0.11877 | 0.22601 | 0.47105 |
|     |   | 3.5 | 0.15284 | 0.14376 | 0.27357 | 0.57016 |
|     |   | 4.5 | 0.15564 | 0.15828 | 0.30390 | 0.61783 |
|     | 3 | 2   | 0.09065 | 0.08296 | 0.15547 | 0.32908 |
|     |   | 2.5 | 0.09374 | 0.09918 | 0.18896 | 0.38187 |
|     |   | 3   | 0.10458 | 0.11065 | 0.21082 | 0.42606 |
|     |   | 3.5 | 0.12659 | 0.13394 | 0.25518 | 0.51571 |
|     |   | 4.5 | 0.16792 | 0.15403 | 0.28875 | 0.61070 |

### HECU Electric Energy Savings

The following table outlines the energy savings associated with each specified unit. Units are in kWh. For the purposes of screening, the savings for each component will be treated separately against its respective loadshape, as described in the Load Shape section.

| Temp   | Phase | HP  | Scroll Compressor | Condenser Fan(s) | Floating Head Pressure Controls | Total  |
|--------|-------|-----|-------------------|------------------|---------------------------------|--------|
| Medium | 1     | 1   | 838.1             | 462.9            | 937.5                           | 2238.5 |
|        |       | 1.5 | 627.8             | 496.0            | 1113.5                          | 2237.4 |
|        |       | 2   | 732.2             | 578.5            | 1298.6                          | 2609.3 |
|        |       | 2.5 | 857.6             | 677.6            | 1521.1                          | 3056.3 |
|        |       | 3   | 828.9             | 861.5            | 2039.3                          | 3729.7 |
|        |       | 3.5 | 1179.8            | 984.0            | 2235.4                          | 4399.1 |
|        |       | 4   | 1304.9            | 1088.3           | 2472.3                          | 4865.4 |
|        |       | 4.5 | 1328.1            | 1107.7           | 2516.3                          | 4952.1 |
|        |       | 5   | 971.9             | 1151.4           | 2780.5                          | 4903.8 |
|        | 3     | 1   | 595.3             | 414.3            | 844.5                           | 1854.1 |
|        |       | 1.5 | 504.7             | 474.7            | 1034.8                          | 2014.2 |
|        |       | 2   | 588.6             | 553.6            | 1206.8                          | 2349.0 |
|        |       | 2.5 | 689.4             | 648.5            | 1413.6                          | 2751.4 |
|        |       | 3   | 709.4             | 793.0            | 1779.0                          | 3281.5 |

|     |   |     |        |        |        |        |
|-----|---|-----|--------|--------|--------|--------|
|     |   | 3.5 | 1056.0 | 90.4   | 1943.3 | 3906.7 |
|     |   | 4   | 1168.0 | 1003.5 | 2149.3 | 4320.8 |
|     |   | 4.5 | 1188.8 | 1021.4 | 2187.6 | 4397.8 |
|     |   | 5   | 1032.0 | 1126.8 | 2518.9 | 4677.6 |
| Low | 1 | 2   | 521.7  | 554.9  | 1208.0 | 2284.5 |
|     |   | 2.5 | 468.4  | 648.0  | 1462.8 | 2579.2 |
|     |   | 3   | 522.6  | 722.9  | 1632.0 | 2877.6 |
|     |   | 3.5 | 632.6  | 875.1  | 1975.4 | 3483.1 |
|     |   | 4.5 | 644.2  | 963.5  | 2194.5 | 3802.2 |
|     | 3 | 2   | 375.2  | 505.0  | 1122.7 | 2002.8 |
|     |   | 2.5 | 388.0  | 603.7  | 1364.5 | 2356.1 |
|     |   | 3   | 432.9  | 673.5  | 1522.3 | 2628.7 |
|     |   | 3.5 | 523.9  | 815.3  | 1842.7 | 3181.9 |
|     |   | 4.5 | 695.0  | 937.6  | 2085.1 | 3717.7 |

**Baseline Efficiency:**

The baseline efficiency case for the HECU measure is a condensing unit with a standard compressor efficiency rating, no floating head pressure controls, and single speed compressor fan motors.

**High Efficiency:**

The high efficiency case for the HECU measure must have scroll compressor technology, incorporate floating head pressure controls, and have the ability to modulate compressor fan speed.

**Measure Life:**

The measure life is 13 years for the HECU.

| Measure Name                    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------|-----------------|-----|-----|-----|-----|-----|
| High Efficiency Condensing Unit | CI_EQUIP        | All | 11  | n/a | n/a | 11  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| High Efficiency Condensing Unit- Scroll compressor | CI_EQUIP        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.9              | 0.9              |

**In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors align with the loadshapes used to capture the coincident peak demand savings associated with the scroll compressor and the floating head pressure control components of the measure, as used in the VT TRM methodology.

**Impact Factors for Calculating Net Savings:**

HECU net savings factors are based on evaluated freeridership and spillover factors for Massachusetts prescriptive C&I New and Replacement Equipment (2021 Omnibus NTG Study).

| Measure Name                     | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|----------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| High Efficiency Condensing Units | CI_EQUIP        | All | 0.250 | 0.002           | 0.085            | 0.837 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

### 3.56. HVAC - Hotel Occupancy Sensor

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-HOS                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

The installation of hotel occupancy sensors (HOS) to control packaged terminal AC units (PTACs) with electric heat, heat pump units, and/or fan coil units in hotels that operate all 12 months of the year.

#### BCR Measure IDs:

| Measure Name           | Core Initiative                           | BCR Measure ID |
|------------------------|-------------------------------------------|----------------|
| Hotel Occupancy Sensor | C&I Existing Building Retrofit (CI_RETRO) | EC2a029        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results:

$$\text{delkWh} = \text{SAVE}_{\text{kWh}}$$

$$\text{delkW} = \text{SAVE}_{\text{kW}}$$

Where:

Unit = Installed hotel room occupancy sensor

$\text{SAVE}_{\text{kWh}}$  = Average annual kWh reduction per unit: 438 kWh<sup>1</sup>

$\text{SAVE}_{\text{kW}}$  = Average annual kWh reduction per unit: 0.09 kW<sup>2</sup>

#### Baseline Efficiency:

The baseline efficiency case assumes the equipment has no occupancy based controls.

#### High Efficiency:

The high efficiency case is the installation of controls that include (a) occupancy sensors, (b) window/door switches for rooms that have operable window or patio doors, and (c) set back to 65 F in the heating mode and set forward to 78° F in the cooling mode when occupancy detector is in the unoccupied mode. Sensors controlled by a front desk system are not eligible.

#### Measure Life:

This measure was determined to be an add on single baseline.<sup>3</sup>

| Measure Name                   | Core Initiative | PA  | EUL | OYF  | RUL | AML |
|--------------------------------|-----------------|-----|-----|------|-----|-----|
| HVAC - Hotel Occupancy Sensors | CI_RETRO        | All | 10  | 1.00 | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                   | Core Initiative | PA             | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------|-----------------|----------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| HVAC - Hotel Occupancy Sensors | CI_RETRO        | National Grid  | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.30             | 0.70             |
| HVAC - Hotel Occupancy Sensors | CI_RETRO        | Eversource CLC | 1.00 | 1.01            | n/a              | 1.09             | 1.57             | 0.82             | 0.05             |
| HVAC - Hotel Occupancy Sensors | CI_RETRO        | Unitil         | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.82             | 0.05             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

- National Grid: RRs based on engineering estimates.
- Eversource (NSTAR), CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations.<sup>4</sup>
- Unitil: Energy and demand RRs are set to 100% due to no formal evaluations have been completed.<sup>5</sup>

**Coincidence Factors:**

- National Grid: CFs based on engineering estimates.<sup>6</sup>
- Eversource, CLC, Unitil: on-peak CFs based on standard assumptions.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>8</sup>

| Measure Name                   | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| HVAC - Hotel Occupancy Sensors | CI_RETRO        | All | 17.9% | 0.3%            | 5.4%             | 87.8% |

**Non-Energy Impacts:**

Prescriptive HVAC measures in retrofit applications have an annual \$/kWh NEI.<sup>9</sup>

| Measure Name                   | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| HVAC - Hotel Occupancy Sensors | CI_RETRO        | All |                    |                      | \$0.222           |                     |                     |                       |

**Endnotes:**

- 1** : MassSave (2010). Energy Analysis: Hotel Guest Occupancy Sensors. Prepared for National Grid and Eversource (NSTAR). [NGRID and NSTAR EnergyAnalysis Hotel Guest Occupancy Sensors](#)
- 2** : MassSave (2010). Energy Analysis: Hotel Guest Occupancy Sensors. Prepared for National Grid and Eversource (NSTAR). [NGRID and NSTAR EnergyAnalysis Hotel Guest Occupancy Sensors](#)
- 3** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet.. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo. [2018 DNVGL ERS Portfolio Model Companion Sheet](#)
- 4** : RLW Analytics (2008). Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report. Prepared for NSTAR Electric and Gas; Table 17 [RLW 2008 Business and Construction Solutions Programs Measurement and Verification 2006 Final Report](#)
- 5** : MA Common Assumption
- 6** : Common Assumption
- 7** : Common Assumption
- 8** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)
- 9** : KEMA, Inc. (2012). Commercial and Industrial Non-Energy Impacts Study. [TETRATECH 2012 MA CI NEI REPORT](#)



### 3.57. HVAC - Infrared Heater

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-IH                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Time of Sale                             |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

The installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equipment. Infrared heating uses radiant heat as opposed to warm air to heat buildings. In commercial environments with high air exchange rates, heat loss is minimal because the space's heat comes from surfaces rather than air.

#### BCR Measure IDs:

| Measure Name          | Core Initiative                                  | BCR Measure ID |
|-----------------------|--------------------------------------------------|----------------|
| Infrared Heaters, Gas | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a024        |
| Infrared Heaters, Gas | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b020        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name     | $\Delta$ MMBtu |
|------------------|----------------|
| Infrared Heaters | 12.0           |

#### Baseline Efficiency:

The baseline efficiency case is a standard efficiency gas-fired unit heater with combustion efficiency of 80%.

#### High Efficiency:

The high efficiency case is a gas-fired low-intensity infrared heating unit.

**Measure Life:**

The measure life is 17 years.<sup>2</sup>

| Measure Name     | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|------------------|----------------------|-----|-----|-----|-----|-----|
| Infrared Heaters | CI_NB&MR<br>CI_EQUIP | All | 17  | n/a | n/a | 17  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name     | Core Initiative      | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|----------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Infrared Heaters | CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Values from 2021 C&I NTG Omnibus study.<sup>3</sup>

| Measure Name     | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------|-----------------|-----|-------|-----------------|------------------|------|
| Infrared Heaters | CI_NB&MR        | All | 0.58  | 0.22            | 0.00             | 0.64 |
| Infrared Heaters | CI_EQUIP        | All | 0.373 | 0.026           | 0.191            | 0.84 |

**Non-Energy Impacts:**

Values sourced for 2021 NEI Study.<sup>4</sup>

| Measure Name     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Infrared Heaters | CI_NB&MR        | All |                    |                      |                   |                     | \$ 2.80             |                       |

**Endnotes:**

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- 1 : KEMA (2013). Impact Evaluation of 2011 Prescriptive Gas Measures; Page 1-5.  
[KEMA 2013 Prescriptive Gas Impact Eval PY2011](#)
- 2 : Nexant (2006). DSM Market Characterization Report. Prepared for Questar Gas.  
[Nexant 2006 DSM Market Characterization Report](#)
- 3 : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)
- 4 : 2021 (NMR) C&I O&M and non-O&M NEI with Small Business Focus

### 3.58. HVAC - Pipe Wrap (Heating)

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-PWS                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Install insulation on steam pipes located in non-conditioned spaces.

#### BCR Measure IDs:

| Measure Name                               | Core Initiative                           | BCR Measure ID |
|--------------------------------------------|-------------------------------------------|----------------|
| Pipe Wrap, Steam, Oil (Turnkey)            | C&I Existing Building Retrofit (CI_RETRO) | E19C2a133      |
| Pipe Wrap, Steam, Propane (Turnkey)        | C&I Existing Building Retrofit (CI_RETRO) | E19C2a134      |
| Pipe Wrap Steam, Gas, <=1.5"               | C&I Existing Building Retrofit (CI_RETRO) | G19C2a026      |
| Pipe Wrap Steam, Gas, 3"                   | C&I Existing Building Retrofit (CI_RETRO) | G19C2a027      |
| Pipe Wrap Steam, Gas , <=1.5"<br>(Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | G19C2a047      |
| Pipe Wrap Steam, Gas , 3" (Turnkey)        | C&I Existing Building Retrofit (CI_RETRO) | G19C2a048      |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on PA calculations.<sup>1</sup>

| Measure Name             | $\Delta$ MMBtu per linear foot |
|--------------------------|--------------------------------|
| Pipe Wrap Steam, <= 1.5" | 0.21                           |
| Pipe Wrap Steam, 3"      | 0.37                           |

#### Baseline Efficiency:

The baseline efficiency case is un-insulated steam piping in unconditioned space.

#### High Efficiency:

The high efficiency condition is steam piping in unconditioned space with insulation installed.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------|-----------------|-----|-----|-----|-----|-----|
| Pipe Wrap Steam | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap Steam | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% non-energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Values are based on an evaluation study.<sup>3</sup>

| Measure Name                   | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Pipe Wrap Steam, Gas           | CI_RETRO        | All | 0.369 | 0.00            | 0.032            | 0.663 |
| Pipe Wrap Steam, Gas (Turnkey) | CI_RETRO        | All | 0.285 | 0.00            | 0.00             | 0.715 |
| Pipe Wrap Steam, Oil           | CI_RETRO        | All | 0.077 | 0.013           | 0.040            | 0.940 |
| Pipe Wrap Steam, Propane       | CI_RETRO        | All | 0.077 | 0.013           | 0.040            | 0.940 |

**Non-Energy Impacts:**NEIs are from 2021 Study.<sup>4</sup>

| Measure Name                        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Pipe Wrap, Gas                      | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.86             |                       |
| Pipe Wrap, Steam, Oil (Turnkey)     | CI_RETRO        | All |                    |                      |                   |                     | \$0.14              |                       |
| Pipe Wrap, Steam, Propane (Turnkey) | CI_RETRO        | All |                    |                      |                   |                     | \$0.14              |                       |

**Endnotes:**

1 : National Grid Staff Calculations (2010). Pipe insulation for SBS DI measures 2010 Workbook.

[NGrid Pipe insulation for SBS DI measures 2010](#)

2 : GDS Associates, Inc (2009). Natural Gas Energy Efficiency Potential in Massachusetts.

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

4 : 2021 (NMR) C&I O&M and non-O&M NEI with Small Business Focus

### 3.59. HVAC - Pipe Wrap (Heating) - C&I Metered Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-PWREU                           |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Install insulation on steam piping located in non-conditioned spaces.

#### BCR Measure IDs:

| Measure Name                                   | Core Initiative                           | BCR Measure ID |
|------------------------------------------------|-------------------------------------------|----------------|
| Pipe Wrap (Heating), Gas (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | GC2a061        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed per linear foot of pipe insulation based on calculation assumptions.<sup>1</sup>

| Measure Name                                   | Δ MMBtu |
|------------------------------------------------|---------|
| Pipe Wrap (Heating), Gas (Residential End Use) | 0.16    |

#### Baseline Efficiency:

The baseline efficiency case is un-insulated heating piping in unconditioned space.

#### High Efficiency:

The high efficiency condition is heating piping in unconditioned space with insulation installed.

#### Measure Life:

The measure life is 15 years.<sup>2</sup>

| Measure Name                                   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Pipe Wrap (Heating), Gas (Residential End Use) | CI_RETRO        | 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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Heating), Gas (Residential End Use) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are from evaluation results.<sup>3</sup>

| Measure Name                                   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Pipe Wrap (Heating), Gas (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

There are no non-energy impacts for this measure.

**Endnotes:**

**1** : National Grid Staff Calculation (2010). Pipe insulation for SBS DI measures 2010 Excel Workbook Savings assumptions from National Grid program vendor for High Rise.

[NGrid Pipe insulation for SBS DI measures 2010](#)

**2** : GDS Associates, Inc (2009). Natural Gas Energy Efficiency Potential in Massachusetts.

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

**3** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.

[2021 Guidehouse MA Res NTG Final Report](#)



### 3.60. HVAC - Programmable Thermostat - C&I Multi-Family

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-PTREU                           |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

Installation of a programmable thermostat, which gives the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.

#### BCR Measure IDs:

| Measure Name                                                                | Core Initiative                           | BCR Measure ID |
|-----------------------------------------------------------------------------|-------------------------------------------|----------------|
| Programmable Thermostat, Gas (Residential End Use)                          | C&I Existing Building Retrofit (CI_RETRO) | GC2a066        |
| Programmable Thermostat, Electric Resistance, No AC (Residential End Use)   | C&I Existing Building Retrofit (CI_RETRO) | E19C2a081      |
| Programmable Thermostat, Electric Resistance, With AC (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | E19C2a082      |
| Programmable Thermostat, AC Only (Residential End Use)                      | C&I Existing Building Retrofit (CI_RETRO) | E19C2a083      |
| Programmable Thermostat, Heat Pump (Residential End Use)                    | C&I Existing Building Retrofit (CI_RETRO) | E19C2a084      |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results<sup>1 2 3</sup>

| Measure Name                                                                | $\Delta kWh$ | $\Delta kW^4$ | $\Delta MMBtu$ |
|-----------------------------------------------------------------------------|--------------|---------------|----------------|
| Programmable Thermostat, Gas (Residential End Use)                          |              |               | 2.07           |
| Programmable Thermostat, Electric Resistance, No AC (Residential End Use)   | 257          | 0.19          |                |
| Programmable Thermostat, Electric Resistance, With AC (Residential End Use) | 281          | 0.13          |                |
| Programmable Thermostat, AC Only (Residential End Use)                      | 25           | 0.04          |                |

|                                                          |     |      |     |
|----------------------------------------------------------|-----|------|-----|
| Programmable Thermostat, Heat Pump (Residential End Use) | 241 | 0.28 |     |
| Programmable Thermostat, Oil (Residential End Use)       |     |      | 2.1 |

**Baseline Efficiency:**

The baseline efficiency case is an HVAC system without a programmable thermostat.

**High Efficiency:**

The high efficiency case is an HVAC system that has a programmable thermostat installed.

**Measure Life:**

The measure life is 19 years.<sup>5</sup> The measure persistence was estimated to be 69%<sup>6</sup> so the effective measure life is 13 years (19 years \* 69%).

| Measure Name                                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Programmable Thermostat (Residential End Use) | CI_RETRO        | All | 19  | n/a | n/a | 13  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Programmable Thermostat, Gas (Residential End Use) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.35             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>8</sup>

| Measure Name                                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-----------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Programmable Thermostat (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B. The thermostat NEI values are per household and the PAs adjust the total value by the average number of thermostats per account depending on the initiative.

| Measure Name                                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Programmable Thermostat (Residential End Use) | CI_RETRO        | All | \$14.35            |                      |                   |                     |                     |                       |

### Endnotes:

1 : Guidehouse (2021). Residential Wi-Fi and Programmable Thermostat Impacts.

[2021 Guidehouse Thermostat Impact Study](#)

2 : Guidehouse (2020) Residential Baseline Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)

5 : [2021 Guidehouse TRM Final Report](#)

6 : The Cadmus Group, Inc. (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Analysis. [CADMUS 2012 Multifamily Impacts Analysis Report](#)

7 : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

8 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products.

[2021 Guidehouse MA Res NTG Final Report](#)

### 3.61. HVAC - Programmable Thermostat, Electric

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-PT                              |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

This measure involves the installation of a programmable thermostat for cooling and/or heating systems in spaces with either no or erratic existing control.

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                           | BCR Measure ID |
|---------------------------------------------|-------------------------------------------|----------------|
| Programmable Thermostat                     | C&I Existing Building Retrofit (CI_RETRO) | E19C2a023      |
| Programmable Thermostat, Electric (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | E19C2a047      |
| Programmable Thermostat, Oil (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | E19C2a126      |
| Programmable Thermostat, Propane (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO) | E19C2a127      |
| Programmable Thermostat, Gas                | C&I Existing Building Retrofit (CI_RETRO) | G19C2a016      |
| Programmable Thermostat, Gas (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | G19C2a037      |

#### Algorithms for Calculating Primary Energy Impact:

$$kWh = (SQFT)(SAVE_{kWh})$$

$$kW = (SQFT)(SAVE_{kW})$$

Where:

SQFT = square feet of controlled space

SAVE<sub>kWh</sub> = average annual kWh reduction per SQFT of controlled (see below)

SAVE<sub>kW</sub> = average kW reduction per SQFT of controlled space (see below)

| Measure Name                                | SAVEkWh (kWh/SqFt) <sup>1</sup> | SAVEkW (kW/SqFt) |
|---------------------------------------------|---------------------------------|------------------|
| PT - Cool Only No Existing Control          | 0.539                           | 0.000            |
| PT - Cool Only Erratic Existing Control     | 0.154                           | 0.000            |
| PT - Heat Only No Existing Control          | 0.418                           | 0.000            |
| PT - Heat Only Erratic Existing Control     | 0.119                           | 0.000            |
| PT - Cool and Heat No Existing Control      | 0.957                           | 0.000            |
| PT - Cool and Heat Erratic Existing Control | 0.273                           | 0.000            |
| PT - Heat Pump No Existing Control          | 0.848                           | 0.000            |
| PT - Heat Pump Erratic Existing Control     | 0.242                           | 0.000            |

Deemed savings for the gas programmable thermostat is 20.7 therms<sup>2</sup>

### Baseline Efficiency:

The baseline efficiency case includes spaces with either no or erratic heating and/or cooling control as indicated in the equipment type selection.

### High Efficiency:

The high efficiency case includes control of the space cooling and/or heating system as indicated in the equipment type selection.

### Measure Life:

The measure life is 15 years.<sup>2</sup>

| Measure Name            | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------|-----------------|-----|-----|-----|-----|-----|
| Programmable Thermostat | CI_RETRO        | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                      | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Programmable Thermostat           | CI_RETRO        | National Grid | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.00             |
| Programmable Thermostat           | CI_RETRO        | Eversource    | 1.00 | 0.91            | n/a              | 0.92             | 0.92             | 0.00             | 0.00             |
| Programmable Thermostat           | CI_RETRO        | CLC           | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.00             |
| Programmable Thermostat           | CI_RETRO        | Unitil        | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.00             | 0.00             |
| Programmable Thermostat (Turnkey) | CI_RETRO        | Eversource    | 1.00 | 0.95            | n/a              | 1.26             | 1.41             | 0.00             | 0.00             |
| Programmable Thermostat (Turnkey) | CI_RETRO        | Unitil        | 1.00 | 0.95            | n/a              | 1.26             | 1.41             | 0.00             | 0.00             |
| Programmable Thermostat (Turnkey) | CI_RETRO        | CLC           | 1.00 | 1.05            | n/a              | 0.94             | 1.17             | 0.00             | 0.00             |
| Programmable Thermostat (Turnkey) | CI_RETRO        | National Grid | 1.00 | 1.05            | n/a              | 0.94             | 1.17             | 0.00             | 0.00             |

**In-Service Rates**

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

**Realization Rates**

Retrofit: RRs set to 100% based on no evaluations.

Retrofit (Turnkey): Realizations Rates come from the Small Business Impact Evaluation<sup>3</sup>

**Coincidence Factors**

All PAs CFs set to zero since no savings are expected during peak periods.

**Impact Factors for Calculating Net Savings:**Values from 2021 C&I NTG study.<sup>4</sup>

| Measure Name                                | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|---------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Programmable Thermostat, Gas                | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.663 |
| Programmable Thermostat, Gas (Turnkey)      | CI_RETRO        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Programmable Thermostat                     | CI_RETRO        | All | 0.18  | 0.00            | 0.05             | 0.880 |
| Programmable Thermostat, Electric (Turnkey) | CI_RETRO        | All | 0.080 | 0.010           | 0.000            | 0.940 |
| Programmable Thermostat, Oil (Turnkey)      | CI_RETRO        | All | 0.080 | 0.010           | 0.000            | 0.940 |
| Programmable Thermostat, Propane (Turnkey)  | CI_RETRO        | All | 0.080 | 0.010           | 0.000            | 0.940 |

**Non-Energy Impacts:**Non-energy impacts are as below<sup>5</sup>.

| Measure Name                                | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Programmable Thermostat                     | CI_RETRO        | All |                    |                      | \$ 0.247          |                     |                     |                       |
| Programmable Thermostat, Electric (Turnkey) | CI_RETRO        | All |                    |                      | \$ 0.247          |                     |                     |                       |
| Programmable Thermostat, Oil (Turnkey)      | CI_RETRO        | All |                    |                      | \$ 0.247          |                     |                     |                       |
| Programmable Thermostat, Propane (Turnkey)  | CI_RETRO        | All |                    |                      | \$ 0.247          |                     |                     |                       |
| Programmable Thermostat, Gas                | CI_RETRO        | All |                    |                      |                   |                     | \$ 2.80             |                       |
| Programmable Thermostat, Gas (Turnkey)      | CI_RETRO        | All |                    |                      |                   |                     | \$ 2.80             |                       |

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**Endnotes:**

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- 1 : All deemed savings values based on Massachusetts common assumptions.
- 2 : 2021 (Guidehouse) WiFi and Programmable Thermostat Impacts
- 2 : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)
- 3 : DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.
- 5 : NMR (2021) C&I OM and non-OM NEI Study



### 3.62. HVAC - Programmable Thermostat, Non-Electric

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-PTG                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | Retrofit                                 |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

This measure involves the installation of a programmable thermostat for cooling and/or heating systems in spaces with either no or erratic existing control.

#### BCR Measure IDs:

| Measure Name                               | Core Initiative                           | BCR Measure ID |
|--------------------------------------------|-------------------------------------------|----------------|
| Programmable Thermostat, Oil (Turnkey)     | C&I Existing Building Retrofit (CI_RETRO) | E19C2a126      |
| Programmable Thermostat, Propane (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | E19C2a127      |
| Programmable Thermostat, Gas               | C&I Existing Building Retrofit (CI_RETRO) | G19C2a016      |
| Programmable Thermostat, Gas (Turnkey)     | C&I Existing Building Retrofit (CI_RETRO) | G19C2a037      |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup>

| Measure Name            | $\Delta$ MMBtu |
|-------------------------|----------------|
| Programmable Thermostat | 2.07           |

#### Baseline Efficiency:

The baseline efficiency case is an HVAC system providing space heating without a programmable thermostat.

#### High Efficiency:

The high efficiency case is an HVAC system providing space heating with a 7-day programmable thermostat installed.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name            | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------|-----------------|-----|-----|-----|-----|-----|
| Programmable Thermostat | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name            | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Programmable Thermostat | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

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

**Realization Rates:**

All PAs use a 100% non-energy realization rate.

**Coincidence Factors:**

n/a as this is not an electric measure.

**Impact Factors for Calculating Net Savings:**

Values from 2021 C&I NTG study.<sup>3</sup>

| Measure Name                           | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|----------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Programmable Thermostat, Gas           | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.663 |
| Programmable Thermostat, Gas (Turnkey) | CI_RETRO        | All | 0.285 | 0.00            | 0.00             | 0.715 |
| Programmable Thermostat, Oil           | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Programmable Thermostat, Propane       | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |

**Non-Energy Impacts:**

Values from 2021 C&I NEI study. <sup>4</sup>

| Measure Name                     | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Programmable Thermostat, Gas     | CI_RETRO        | All |                    |                      |                   |                     | \$ 2.80             |                       |
| Programmable Thermostat, Oil     | CI_RETRO        | All |                    |                      | \$ 0.25           |                     |                     |                       |
| Programmable Thermostat, Propane | CI_RETRO        | All |                    |                      | \$ 0.25           |                     |                     |                       |

**Endnotes:**

2 : Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat.

[EPA 2010 Lifecycle Cost Estimate for ENERGY STAR Programmable Thermostats](#)

### 3.63. HVAC - Unitary Air Conditioner

|                     |                                          |
|---------------------|------------------------------------------|
| <b>Measure Code</b> | COM-HVAC-UAC                             |
| <b>Market</b>       | Commercial                               |
| <b>Program Type</b> | New Construction                         |
| <b>Category</b>     | Heating Ventilation and Air Conditioning |

#### Measure Description:

This measure promotes the installation of high efficiency unitary air conditioning equipment in lost opportunity applications. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure applies to air, water, and evaporatively-cooled unitary AC systems, both single-package and split systems.

#### BCR Measure IDs:

| Measure Name                         | Core Initiative                            | BCR Measure ID |
|--------------------------------------|--------------------------------------------|----------------|
| Midstream - Unitary Air Conditioners | C&I New & Replacement Equipment (CI_EQUIP) | EC2b051        |

#### Algorithms for Calculating Primary Energy Impact:

For units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = (kBtu/h) (1/SEER_{base} - 1/SEER_{ee}) (EFLH_{cool})$$

$$\Delta kW = (kBtu/h) (1/EER_{base} - 1/EER_{ee})$$

For units with cooling capacities equal to or greater than 65 kBtu/h and EER available:

$$\Delta kWh = (kBtu/h) (1/EER_{base} - 1/EER_{ee}) (EFLH_{cool})$$

$$\Delta kW = (kBtu/h) (1/EER_{base} - 1/EER_{ee})$$

For units with cooling capacities equal to or greater than 65 kBtu/h and IEER available:

$$\Delta kWh = (kBtu/h) (1/IEER_{base} - 1/IEER_{ee}) (Hours_{cool}) (Capadj)$$

$$\Delta kW = (kBtu/h) (1/EER_{base} - 1/EER_{ee})$$

Where;

$\Delta kWh$  = Gross annual kWh savings from the measure.

$\Delta kW$  = Gross connected kW savings from the measure.

kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h)

SEERBASE = Seasonal Energy Efficiency Ratio of the baseline equipment.

SEEREE = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

EFLHcool = Cooling equivalent full load hours.

EERBASE = Energy Efficiency Ratio of the baseline equipment.

EEREE = Energy Efficiency Ratio of the energy efficient equipment.

IEERBASE = Integrated Energy Efficiency Ratio of the baseline equipment.

IEEREE = Integrated Energy Efficiency Ratio of the energy efficient equipment.  
 HoursCool = Annual Cooling Hours  
 Capadj = Capacity Adjustment Factor<sup>1</sup>

**PA specific Capacity Adjustment Factors for IEER**

| PA                | Capacity Adjustment Factor |
|-------------------|----------------------------|
| National Grid     | 1.009                      |
| Eversource<br>CLC | 0.927                      |
| Unitil            | 1.104                      |

**Baseline Efficiency:**

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by IECC 2018.

A/C Baseline Efficiency Requirements

| Equipment Type                       | Size Category                       | Heating Section Type          | Subcategory or Rating Condition | Minimum Efficiency    | Test Procedure  |
|--------------------------------------|-------------------------------------|-------------------------------|---------------------------------|-----------------------|-----------------|
| Air conditioners, air cooled         | < 65,000 Btu/h                      | All                           | Split System                    | 13.0 SEER             | AHRI<br>210/240 |
|                                      |                                     |                               | Single Package                  | 14.0 SEER             |                 |
| Through-the-wall (air cooled)        | ≤ 30,000 Btu/h                      | All                           | Split system                    | 12.0 SEER             |                 |
|                                      |                                     |                               | Single Package                  | 12.0 SEER             |                 |
| Small duct high velocity, air cooled | ≤ 65,000 Btu/h                      | All                           | Split system                    | 11.0 SEER             |                 |
| Air conditioners, air cooled         | ≥ 65,000 Btu/h and < 135,000 Btu/h  | Electric Resistance (or None) | Split System and Single Package | 11.2 EER<br>12.9 IEER |                 |
|                                      |                                     | All other                     | Split System and Single Package | 11.0 EER<br>12.7 IEER |                 |
|                                      | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.0 EER<br>12.4 IEER |                 |
|                                      |                                     | All other                     | Split System and Single Package | 10.8 EER<br>12.2 IEER |                 |

|                                                 |                                                  |                                  |                                    |                                    |                 |                       |
|-------------------------------------------------|--------------------------------------------------|----------------------------------|------------------------------------|------------------------------------|-----------------|-----------------------|
|                                                 | $\geq 240,000$ Btu/h<br>and<br>$< 760,000$ Btu/h | Electric Resistance<br>(or None) | Split System and<br>Single Package | 10.0 EER<br>11.6 IEER              |                 |                       |
|                                                 |                                                  | All other                        | Split System and<br>Single Package | 9.8 EER<br>11.4 IEER               |                 |                       |
|                                                 | $\geq 760,000$ Btu/h                             | Electric Resistance<br>(or None) | Split System and<br>Single Package | 9.7 EER<br>11.2 IEER               |                 |                       |
|                                                 |                                                  | All other                        | Split System and<br>Single Package | 9.5 EER<br>11.0 IEER               |                 |                       |
| Air conditioners,<br>water cooled               | $< 65,000$ Btu/h                                 | All                              | Split System and<br>Single Package | 12.1 EER<br>12.3 IEER              | AHRI<br>210/240 |                       |
|                                                 | $\geq 65,000$ Btu/h<br>and<br>$< 135,000$ Btu/h  | Electric Resistance<br>(or None) | Split System and<br>Single Package | 12.1 EER<br>13.9 IEER              | AHRI<br>340/360 |                       |
|                                                 |                                                  | All other                        | Split System and<br>Single Package | 11.9 EER<br>13.7 IEER              |                 |                       |
|                                                 | $\geq 135,000$ Btu/h<br>and<br>$< 240,000$ Btu/h | Electric Resistance<br>(or None) | Split System and<br>Single Package | 12.5 EER<br>13.9 IEER              |                 |                       |
|                                                 |                                                  | All other                        | Split System and<br>Single Package | 12.3 EER<br>13.7 IEER              |                 |                       |
|                                                 | $\geq 240,000$ Btu/h<br>and<br>$< 760,000$ Btu/h | Electric Resistance<br>(or None) | Split System and<br>Single Package | 12.4 EER<br>13.6 IEER              |                 |                       |
|                                                 |                                                  | All other                        | Split System and<br>Single Package | 12.2 EER<br>13.4 IEER              |                 |                       |
|                                                 | $\geq 760,000$ Btu/h                             | Electric Resistance<br>(or None) | Split System and<br>Single Package | 12.2 EER<br>13.5 IEER              |                 |                       |
|                                                 |                                                  | All other                        | Split System and<br>Single Package | 12.0 EER<br>13.3 IEER              |                 |                       |
|                                                 | Air conditioners,<br>evaporatively<br>cooled     | $< 65,000$ Btu/h                 | All                                | Split System and<br>Single Package |                 | 12.1 EER<br>12.3 IEER |
| $\geq 65,000$ Btu/h<br>and<br>$< 135,000$ Btu/h |                                                  | Electric Resistance<br>(or None) | Split System and<br>Single Package | 12.1 EER<br>12.3 IEER              |                 | AHRI<br>340/360       |

|                                        |                                     |                               |                                 |                       |          |
|----------------------------------------|-------------------------------------|-------------------------------|---------------------------------|-----------------------|----------|
|                                        |                                     | All other                     | Split System and Single Package | 11.9 EER<br>12.1 IEER |          |
|                                        | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 12.0 EER<br>12.2 IEER |          |
|                                        |                                     | All other                     | Split System and Single Package | 11.8 EER<br>12.0 IEER |          |
|                                        | ≥ 240,000 Btu/h and < 760,000 Btu/h | Electric Resistance (or None) | Split System and Single Package | 11.9 EER<br>12.1 IEER |          |
|                                        |                                     | All other                     | Split System and Single Package | 11.7 EER<br>11.9 IEER |          |
|                                        | ≥ 760,000 Btu/h                     | Electric Resistance (or None) | Split System and Single Package | 11.7 EER<br>11.9 IEER |          |
|                                        |                                     | All other                     | Split System and Single Package | 11.5 EER<br>11.7 IEER |          |
| Condensing units, air cooled           | ≥ 135,000 Btu/h                     |                               |                                 | 10.5 EER<br>11.8 IEER | AHRI 365 |
| Condensing units, water cooled         | ≥ 135,000 Btu/h                     |                               |                                 | 13.5 EER<br>14.0 IEER |          |
| Condensing units, evaporatively cooled | ≥ 135,000 Btu/h                     |                               |                                 | 13.5 EER<br>14.0 IEER |          |

### High Efficiency:

The high efficiency case assumes the HVAC equipment meets or exceeds the Consortium for Energy Efficiency's (CEE) specification. This specification results in cost-effective energy savings by specifying higher efficiency HVAC equipment while ensuring that several manufacturers produce compliant equipment. The CEE specification is reviewed and updated annually to reflect changes to the ASHRAE and IECC energy code baseline as well as improvements in the HVAC equipment technology. Equipment efficiency is the rated efficiency of the installed equipment for each project.

### Measure Life:

The measure life is 12 years.

| Measure Name | Core Initiative | PA | EUL | OYF | RUL | AML |
|--------------|-----------------|----|-----|-----|-----|-----|
|--------------|-----------------|----|-----|-----|-----|-----|

|            |          |     |    |     |     |    |
|------------|----------|-----|----|-----|-----|----|
| Unitary AC | CI_EQUIP | All | 12 | n/a | n/a | 12 |
|------------|----------|-----|----|-----|-----|----|

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure    | Core Initiative | PA            | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------|-----------------|---------------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Unitary AC | CI_EQUIP        | CLC           | 1.00 | 1.00            | 1.00             | 0.74             | 0.00             | 0.45             | 0.00             |
| Unitary AC | CI_EQUIP        | National Grid | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.40             | 0.00             |
| Unitary AC | CI_EQUIP        | Eversource    | 1.00 | 1.00            | 1.00             | 0.74             | 0.00             | 0.45             | 0.00             |
| Unitary AC | CI_EQUIP        | Unitil        | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.33             | 0.00             |

**In-Service Rates:**

All installations have 100% in service rate since all programs include verification of equipment installations.

**Realization Rates:**

Energy RRs set to 1.00 based 2011 NEEP C&I Unitary HVAC Loadshape Project.<sup>3</sup>

**Coincidence Factors:**

CFs based 2011 NEEP C&I Unitary HVAC Loadshape Project.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

NTG values were developed as part of an upstream HVAC NTG study in 2021 in Massachusetts.<sup>5</sup>

| Measure                                          | Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------------|------------|-----|------|-----------------|------------------|------|
| HVAC - Upstream - Unitary Air Conditioner - 2022 | CI_EQUIP   | All | 0.45 | 0.00            | 0.00             | 0.55 |
| HVAC - Upstream - Unitary Air Conditioner - 2023 | CI_EQUIP   | All | 0.45 | 0.00            | 0.00             | 0.55 |
| HVAC - Upstream - Unitary Air Conditioner - 2024 | CI_EQUIP   | All | 0.45 | 0.00            | 0.00             | 0.55 |

**Non-Energy Impacts:**

| Measure Name                   | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|--------------------------------|-----------------|-----|-------------------|---------------------|
| HVAC - Unitary Air Conditioner | CI_EQUIP        | All | \$0.135           |                     |

**Endnotes:**



**1** : The capacity adjustment factor is used only when IEER is used to determine energy savings. Since IEER takes into account performance at different loading points, the capacity adjustment factor helps to account for the fact that more load occurs at lower temperatures and capacities. The adjustment factor is greater than 1 for climate zones with lower full load hours and runtime, and the factor is less than 1 for zones with more full load hours and runtime.

**3** : KEMA (2011). C&I Unitary HVAC Loadshape Project.

[KEMA 2011 CIUnitaryHVACLoadShapeProject](#)

**4** : KEMA (2011). C&I Unitary HVAC Loadshape Project.

[KEMA 2011 CIUnitaryHVACLoadShapeProject](#)

**5** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.64. Hot Water - Condensing Water Heater

|                     |                    |
|---------------------|--------------------|
| <b>Measure Code</b> | COM-WH-CWH         |
| <b>Market</b>       | Commercial         |
| <b>Program Type</b> | Replace on Burnout |
| <b>Category</b>     | Water Heating      |

#### Measure Description:

Installation of a high-efficiency gas-fired water heater.

#### BCR Measure IDs:

| Measure Name                             | Core Initiative                            | BCR Measure ID |
|------------------------------------------|--------------------------------------------|----------------|
| Water Heater, Condensing, Gas - Upstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b025        |

#### Algorithms for Calculating Primary Energy Impact:

Savings values are tied to unit Mbtuh.<sup>1</sup>

| Measure Name                                 | ΔMMBtu |
|----------------------------------------------|--------|
| Condensing Water Heater, Gas 0.94 - Upstream | 0.1441 |

#### Baseline Efficiency:

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC). For condensing stand-alone water heaters, the assumed baseline is a stand-alone tank water heater with a thermal efficiency of 80%.<sup>2</sup>

#### High Efficiency:

The high efficiency case is a condensing stand alone commercial water heater with a thermal efficiency of 94% or greater and a capacity greater than 75,000 Btu.

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                                 | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Condensing Water Heater, Gas 0.94 - Upstream | CI_EQUIP        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                 | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Condensing Water Heater, Gas 0.94 - Upstream | CI_Equip        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in-service rates since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rates. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Values based on 2021 C&I Upstream HVAC NTG study.<sup>4</sup>

| Measure Name                            | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | 2022 NTG | 2023 NTG | 2024 NTG |
|-----------------------------------------|-----------------|-----|------|-----------------|------------------|----------|----------|----------|
| Condensing Water Heater, Gas - Upstream | CI_Equip        | All | 0.71 |                 |                  | 0.29     | 0.29     | 0.29     |

**Non-Energy Impacts:**

| Measure Name                        | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|-------------------------------------|-----------------|-----|-------------------|---------------------|
| Hot Water - Condensing Water Heater | CI_EQUIP        | All |                   | \$0.079             |

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**Endnotes:**

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**1** : Unit savings are unevaluated and developed by upstream subcommittee in response to NTG findings going into the 2019-2021 plan. Original savings set lower HE thresholds, though NTG results suggested establishing higher thresholds to ensure the program was targeting the right units. Efficiency threshold increased from 90% AFUE to 94% AFUE.

**2** : Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

**3** : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Page 2 of Appendix B-2, measure GDS C-WH-4. The GDS study references “ACEEE (2004). Emerging technologies and practices; W1 - pg 46.”

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

**4** : DNV GL (2018). C&I Upstream HVAC NTG Study. [2018 DNVGL Upstream HVAC NTG](#)

### 3.65. Hot Water - Faucet Aerator

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-FA     |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Installation of a faucet aerator with a flow rate of 1.5 GPM or less on an existing faucet with high flow in a commercial setting with service water heated by natural gas.

#### BCR Measure IDs:

| Measure Name                       | Core Initiative                           | BCR Measure ID |
|------------------------------------|-------------------------------------------|----------------|
| Faucet Aerator, Electric (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a138        |
| Faucet Aerator, Oil (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a139        |
| Faucet Aerator, Propane (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO) | EC2a140        |
| Faucet Aerator, Gas                | C&I Existing Building Retrofit (CI_RETRO) | GC2a021        |
| Faucet Aerator, Gas (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a042        |

#### Algorithms for Calculating Primary Energy Impact:

Unit gas savings are deemed based on study results<sup>1,2</sup>

| Measure Name             | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|--------------------------|--------------|-------------|----------------|
| Faucet Aerator, Gas      |              |             | 1.7            |
| Faucet Aerator, Electric | 348          | 0.08        |                |
| Faucet Aerator, Oil      |              |             | 1.7            |
| Faucet Aerator, Propane  |              |             | 1.7            |

#### Baseline Efficiency:

The baseline efficiency case is a 2.2 GPM faucet.<sup>3</sup>

#### High Efficiency:

The high efficiency case is a faucet with 1.5 GPM or less aerator installed.<sup>4</sup>

**Measure Life:**

The measure life is 3 years.<sup>5</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Faucet Aerator | CI_RETRO        | All | 10  | n/a | n/a | 3   |

**Other Resource Impacts:**

There are deemed water savings of 5,460 gallons/unit.<sup>6</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Faucet Aerator, Electric (Turnkey) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy and demand realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>7</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>8</sup>

| Measure Name                  | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Faucet Aerator, Gas           | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.663 |
| Faucet Aerator, Gas (Turnkey) | CI_RETRO        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Faucet Aerator, Electric      | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Faucet Aerator, Oil           | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Faucet Aerator, Propane       | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |

**Non-Energy Impacts:**

Non-energy impacts identified for this measure are as below.<sup>9</sup>

| Measure Name                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Faucet Aerator, Gas           | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.357            |                       |
| Faucet Aerator, Gas (Turnkey) | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.357            |                       |

**Endnotes:**

- 1 : [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 2 : mmBTU for delivered fuels assumed to be 1:1 with already existing gas measure.
- 3 : Table B-2a. [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 4 : Table B-2a [GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)
- 6 : Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads.
- 7 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
- 9 : 2021 (NMR) C&I O&M and non-O&M NEI with Small Business Focus

### 3.66. Hot Water - Faucet Aerator - C&I Metered Multi-Family

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-FAREU  |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

An existing faucet aerator with a high flow rate is replaced with a new low flow aerator.

#### BCR Measure IDs:

| Measure Name                                   | Core Initiative                           | BCR Measure ID |
|------------------------------------------------|-------------------------------------------|----------------|
| Faucet Aerator, Electric (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a066        |
| Faucet Aerator, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a067        |
| Faucet Aerator, Oil (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a068        |
| Faucet Aerator, Other (Residential End Use)    | C&I Existing Building Retrofit (CI_RETRO) | EC2a069        |
| Faucet Aerator, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a062        |

#### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                                   | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|------------------------------------------------|--------------|-------------|----------------|
| Faucet Aerator, Electric (Residential End Use) | 97.0         | 0.02        |                |
| Faucet Aerator, Gas (Residential End Use)      |              |             | 0.86           |
| Faucet Aerator, Oil (Residential End Use)      |              |             | 0.86           |
| Faucet Aerator, Other (Residential End Use)    |              |             | 0.86           |



**Baseline Efficiency:**

The baseline efficiency case is the existing faucet aerator with a high flow.

**High Efficiency:**

The high efficiency case is a low flow faucet aerator having a maximum flow rate of 1.5 GPM.

**Measure Life:**

The measure life is 7 years.<sup>3</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Faucet Aerator | CI_RETRO        | All | 7   | n/a | n/a | 7   |

**Other Resource Impacts:**

Residential water savings for faucet aerators is 332 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name   | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Faucet Aerator | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>6</sup>

| Measure Name                         | Core Initiative | PA  | FR   | SOP | SONP | NTG  |
|--------------------------------------|-----------------|-----|------|-----|------|------|
| Faucet Aerator (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0 | 0.0  | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Faucet Aerator (Residential End Use) | CI_RETRO        | All | 0.58               | 0.00                 | 0.00              | 0.00                | 0.00                | 0.00                  |

**Endnotes:**

- 1** : The Cadmus Group (2012). Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 2** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3** : MA Common Assumptions
- 4** : NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. [Tetra Tech and NMR 2011 MA Res and LI NEI Evaluation](#)
- 5** : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 6** : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

### 3.67. Hot Water - Indirect Water Heater

|                     |                    |
|---------------------|--------------------|
| <b>Measure Code</b> | COM-WH-IWH         |
| <b>Market</b>       | Commercial         |
| <b>Program Type</b> | Replace on Burnout |
| <b>Category</b>     | Water Heating      |

#### Measure Description:

Indirect water heaters use a storage tank that is heated by the main boiler. The energy stored by the water tank allows the boiler to turn off and on less often, saving considerable energy.

#### BCR Measure IDs:

| Measure Name                           | Core Initiative                            | BCR Measure ID |
|----------------------------------------|--------------------------------------------|----------------|
| Water Heater, Indirect, Gas - Upstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b023        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed per unit and based on study results.<sup>1</sup>

| Measure Name                          | ΔMMBtu |
|---------------------------------------|--------|
| Indirect Water Heater, Gas - Upstream | 19.0   |

#### Baseline Efficiency:

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC). For indirect water heaters the baseline is a hot water boiler operating at 78% recovery efficiency. Additionally a baseline storage water heater was assumed for purposes of estimating standby losses.<sup>2</sup>

#### High Efficiency:

The high efficiency scenario is an indirect water heater with a Combined Appliance Efficiency (CAE) of 85% or greater.

#### Measure Life:

The measure life is 15 years.<sup>3</sup>

| Measure Name                          | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Indirect Water Heater, Gas - Upstream | CI_EQUIP        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Indirect Water Heater, Gas - Upstream | CI_EQUIP        | All | 1.00 | 1.00            | n/a              | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Values based on 2021 MA C&I Upstream HVAC NTG study.<sup>4</sup>

| Measure Name                          | Core Initiative | PA  | FR  | 2022 NTG | 2023 NTG | 2024 NTG |
|---------------------------------------|-----------------|-----|-----|----------|----------|----------|
| Indirect Water Heater, Gas - Upstream | CI_EQUIP        | All | 64% | 36%      | 36%      | 36%      |

**Non-Energy Impacts:**

| Measure Name                      | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|-----------------------------------|-----------------|-----|-------------------|---------------------|
| Hot Water - Indirect Water Heater | CI_EQUIP        | All |                   | \$0.079             |

**Endnotes:**

1 : KEMA (2013). Impact Evaluation of 2011 Prescriptive Gas Measures; Page 1-6

[KEMA 2013 Prescriptive Gas Impact Eval PY2011](#)

2 : Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010.

3 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts

[GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)

4 : DNVGL (2018). C&I Upstream HVAC NTG [2018 DNVGL Upstream HVAC NTG](#)

### 3.68. Hot Water - Low-Flow Showerhead

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-LFSH   |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Installation of a low flow showerhead with a flow rate of 1.5 GPM or less in a commercial setting with service water heated by natural gas.

#### BCR Measure IDs:

| Measure Name                            | Core Initiative                           | BCR Measure ID |
|-----------------------------------------|-------------------------------------------|----------------|
| Low-Flow Showerhead, Electric           | C&I Existing Building Retrofit (CI_RETRO) | EC2a042        |
| Low-Flow Showerhead, Electric (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a141        |
| Low-Flow Showerhead, Oil (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a142        |
| Low-Flow Showerhead, Propane (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO) | EC2a143        |
| Low-Flow Showerhead, Gas                | C&I Existing Building Retrofit (CI_RETRO) | GC2a022        |
| Low-Flow Showerhead, Gas (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a043        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed.<sup>1</sup> mmBTU savings for delivered fuels assumed to be in a 1:1 ratio with already existing gas measure.

| Measure Name                  | $\Delta kWh$ | $\Delta kW$ | $\Delta MMBtu$ |
|-------------------------------|--------------|-------------|----------------|
| Low-Flow Showerhead, Electric | 513          | 0.09        |                |
| Low-Flow Showerhead, Gas      |              |             | 2.65           |
| Low-Flow Showerhead, Oil      |              |             | 2.65           |

|                              |  |  |      |
|------------------------------|--|--|------|
| Low-Flow Showerhead, Propane |  |  | 2.65 |
|------------------------------|--|--|------|

**Baseline Efficiency:**

The baseline efficiency case is a 2.5 GPM showerhead.

**High Efficiency:**

The high efficiency case is a 1.5 GPM showerhead.

**Measure Life:**

The measure life is 7 years.<sup>2</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead | CI_RETRO        | All | 10  | n/a | n/a | 7   |

**Other Resource Impacts:**

It is assumed that 7,300 gallons/unit are saved.<sup>3</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead, Electric | CI_RETRO        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.81             |
| Low-Flow Showerhead, Gas      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Oil      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Propane  | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy, demand, and non-energy realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-Gross values are based on evaluation results.<sup>5</sup>

| Measure Name                            | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-----------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Low-Flow Showerhead, Electric           | CI_RETRO        | All | 0.179 | 0.03            | 0.054            | 0.878 |
| Low-Flow Showerhead, Electric (Turnkey) | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Low-Flow Showerhead, Gas                | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.664 |
| Low-Flow Showerhead, Gas (Turnkey)      | CI_RETRO        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Low-Flow Showerhead, Oil (Turnkey)      | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Low-Flow Showerhead, Propane (Turnkey)  | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |

### Non-Energy Impacts:

C&I values from 2021 C&I NEI study.<sup>6</sup>

| Measure Name                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead, Electric | CI_RETRO        | All |                    |                      |                   | \$ 0.004            |                     |                       |
| Low-Flow Showerhead, Gas      | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.36             |                       |
| Low-Flow Showerhead, Oil      | CI_RETRO        | All |                    |                      |                   | \$ 0.004            |                     |                       |
| Low-Flow Showerhead, Propane  | CI_RETRO        | All |                    |                      |                   | \$ 0.004            |                     |                       |

### Endnotes:

**1** : Department of Energy Calculator for Faucets & Showerheads.

<https://www.energy.gov/eere/femp/energy-cost-calculator-faucets-and-showerheads-0> Subsequently revised for lower anticipated hot water use. Baseline values were used with the exception of hot water use. This was changed from 100% to 50%.

**3** : Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads.

**4** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

### 3.69. Hot Water - Low-Flow Showerhead - C&I Metered Multi-Family

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-SREU   |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

An existing showerhead with a high flow rate is replaced with a new low flow showerhead.

#### BCR Measure IDs:

| Measure Name                                        | Core Initiative                           | BCR Measure ID |
|-----------------------------------------------------|-------------------------------------------|----------------|
| Low-Flow Showerhead, Electric (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a070        |
| Low-Flow Showerhead, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a071        |
| Low-Flow Showerhead, Oil (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a072        |
| Low-Flow Showerhead, Other (Residential End Use)    | C&I Existing Building Retrofit (CI_RETRO) | EC2a073        |
| Low-Flow Showerhead, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a063        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.<sup>1</sup> kW savings are calculated using the Demand Impact Model.<sup>2</sup>

| Measure Name                                        | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|-----------------------------------------------------|--------------|-------------|----------------|
| Low-Flow Showerhead, Electric (Residential End Use) | 129.0        | 0.03        |                |
| Low-Flow Showerhead, Gas (Residential End Use)      |              |             | 1.14           |
| Low-Flow Showerhead, Oil (Residential End Use)      |              |             | 1.14           |
| Low-Flow Showerhead, Other (Residential End Use)    |              |             | 1.14           |



**Baseline Efficiency:**

The baseline efficiency case is the existing showerhead with a baseline flow rate of 2.5 GPM.

**High Efficiency:**

The high efficiency case is a low flow showerhead having a maximum flow rate between 1.5 and 1.7 GPM.

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name        | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------|-----------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

Water savings for Single Family are 2,401 gallons per unit and for Attached Low Rise and High Rise water savings are 2,165 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead, Electric (Residential End Use) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | 0.31             | 0.84             |
| Low-Flow Showerhead, Gas (Residential End Use)      | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Oil (Residential End Use)      | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Low-Flow Showerhead, Other (Residential End Use)    | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate.

**Coincidence Factors:**

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.<sup>5</sup>

### Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.<sup>6</sup>

| Measure Name                              | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Low-Flow Showerhead (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead (Residential End Use) | CI_RETRO        | All | 0.58               | 0.00                 | 0.00              | 0.00                | 0.00                | 0.00                  |

### Endnotes:

- 1 : The Cadmus Group (2012). Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013. [CADMUS 2012 Multifamily Impacts Analysis Report](#)
- 2 : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 3 : [2021 Guidehouse TRM Final Report](#)
- 4 : Staff calculations based on the methodology from The Cadmus Group, Inc. (2012). Home Energy Services Impact Evaluation. [CADMUS 2012 HES Impact Evaluation Report](#)
- 5 : Navigant Consulting (2018). Demand Impact Model Update. [2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 6 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

### 3.70. Hot Water - Low-Flow Showerhead with Thermostatic Valve - C&I Metered Multi-Family

|                     |                |
|---------------------|----------------|
| <b>Measure Code</b> | COM-WH-STV-REU |
| <b>Market</b>       | Commercial     |
| <b>Program Type</b> | Retrofit       |
| <b>Category</b>     | Water Heating  |

#### Measure Description:

An existing showerhead is replaced with a low-flow showerhead with an integrated thermostatic shut-off valve (TSV).

#### BCR Measure IDs:

| Measure Name                                                 | Core Initiative                           | BCR Measure ID |
|--------------------------------------------------------------|-------------------------------------------|----------------|
| Low-Flow Showerhead with TSV, Electric                       | C&I Existing Building Retrofit (CI_RETRO) | EC2a041        |
| Low-Flow Showerhead with TSV, Electric (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a074        |
| Low-Flow Showerhead with TSV, Oil (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a075        |
| Low-Flow Showerhead with TSV, Other (Residential End Use)    | C&I Existing Building Retrofit (CI_RETRO) | EC2a076        |
| Low-Flow Showerhead with TSV, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a064        |

#### Algorithms for Calculating Primary Energy Impact:

Unit kWh and MMBtu savings are deemed.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

| Measure Name                           | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|----------------------------------------|--------------|-------------|----------------|
| Low-Flow Showerhead with TSV, Gas      |              |             | 1.41           |
| Low-Flow Showerhead with TSV, Electric | 183          | 0.04        |                |
| Low-Flow Showerhead with TSV, Oil      |              |             | 1.44           |
| Low-Flow Showerhead with TSV, Other    |              |             | 1.41           |

**Baseline Efficiency:**

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

**High Efficiency:**

The high efficiency case is a low-flow showerhead (1.5 GPM) with integrated thermostatically actuated valve.

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                 | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------------|-----------------|-----|-----|-----|-----|-----|
| Low-Flow Showerhead with TSV | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

Water savings are 2,723 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                 | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Low-Flow Showerhead with TSV | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |

**In-Service Rates:**

All installations have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% for deemed measures.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>6</sup>

| Measure Name                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Low-Flow Showerhead with TSV | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name                 | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Low-Flow Showerhead with TSV | CI_RETRO        | All | \$0.58             |                      |                   |                     |                     |                       |

**Endnotes:**

- 1 : [2021 Guidehouse TRM Final Report](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : [2021 Guidehouse TRM Final Report](#)
- 4 : National Grid (2014). Review of ShowerStart evolve. [National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 5 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 6 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

### 3.71. Hot Water - Pipe Wrap (Water Heating)

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-PWWH   |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Install insulation on hot water located in non-conditioned spaces.

#### BCR Measure IDs:

| Measure Name                                     | Core Initiative                           | BCR Measure ID |
|--------------------------------------------------|-------------------------------------------|----------------|
| Pipe Wrap, Hot Water, Electric (Turnkey)         | C&I Existing Building Retrofit (CI_RETRO) | E19C2a135      |
| Pipe Wrap, Hot Water, Oil (Turnkey)              | C&I Existing Building Retrofit (CI_RETRO) | E19C2a136      |
| Pipe Wrap, Hot Water, Propane (Turnkey)          | C&I Existing Building Retrofit (CI_RETRO) | E19C2a137      |
| Pipe Wrap (Water Heating), Gas, <=1.5"           | C&I Existing Building Retrofit (CI_RETRO) | G19C2a024      |
| Pipe Wrap (Water Heating), Gas, 2"               | C&I Existing Building Retrofit (CI_RETRO) | G19C2a025      |
| Pipe Wrap (Water Heating), Gas, <=1.5" (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | G19C2a045      |
| Pipe Wrap (Water Heating), Gas, 2" (Turnkey)     | C&I Existing Building Retrofit (CI_RETRO) | G19C2a046      |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on PA calculations.<sup>1</sup>

| Measure Name                                        | ΔMMBtu per linear foot | ΔkWh | ΔkW  |
|-----------------------------------------------------|------------------------|------|------|
| Pipe Wrap (Water Heating), Gas/Oil/Propane, <= 1.5" | 0.21                   |      |      |
| Pipe Wrap (Water Heating), Gas/Oil/Propane, 2"      | 0.36                   |      |      |
| Pipe Wrap (Water Heating), Electric, <= 1.5"        |                        | 20   | 0.01 |

|                                         |  |    |      |
|-----------------------------------------|--|----|------|
| Pipe Wrap (Water Heating), Electric, 2" |  | 35 | 0.01 |
|-----------------------------------------|--|----|------|

**Baseline Efficiency:**

The baseline efficiency case is un-insulated hot water piping in unconditioned space.

**High Efficiency:**

The high efficiency condition is hot water piping in unconditioned space with insulation installed.

**Measure Life:**

The measure life is 15 years.<sup>2</sup>

| Measure Name              | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------|-----------------|-----|-----|-----|-----|-----|
| Pipe Wrap (Water Heating) | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                        | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Water Heating), Gas      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Electric | CI_RETRO        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.81             |
| Pipe Wrap (Water Heating), Oil      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pipe Wrap (Water Heating), Propane  | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy, demand, and non-energy realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>3</sup>

**Impact Factors for Calculating Net Savings:**

Values are based on an evaluation study.<sup>4</sup>

| Measure Name                                  | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-----------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Pipe Wrap (Water Heating), Gas                | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.663 |
| Pipe Wrap (Water Heating), Gas (Turnkey)      | CI_RETRO        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Pipe Wrap (Water Heating), Electric (Turnkey) | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Pipe Wrap (Water Heating), Oil (Turnkey)      | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Pipe Wrap (Water Heating), Propane (Turnkey)  | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |

### Non-Energy Impacts:

C&I values from 2021 C&I NEI Study.<sup>5</sup>

| Measure Name                                  | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Pipe Wrap (Water Heating), Gas                | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.08             |                       |
| Pipe Wrap (Water Heating), Gas (Turnkey)      | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.86             |                       |
| Pipe Wrap (Water Heating), Electric (Turnkey) | CI_RETRO        | All |                    |                      | 0.14              |                     |                     |                       |
| Pipe Wrap (Water Heating), Oil (Turnkey)      | CI_RETRO        | All |                    |                      | 0.14              |                     |                     |                       |
| Pipe Wrap (Water Heating), Propane (Turnkey)  | CI_RETRO        | All |                    |                      | 0.14              |                     |                     |                       |

### Endnotes:

**1** : National Grid Staff Calculation (2010). Pipe insulation for SBS DI measures 2010 Excel Workbook.

[NGrid Pipe insulation for SBS DI measures 2010](#)

**2** : GDS Associates, Inc (2009). Natural Gas Energy Efficiency Potential in Massachusetts

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

**3** : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

**5** : 2021 (NMR) C&I O&M and non-O&M NEI with Small Business Focus



### 3.72. Hot Water - Pipe Wrap (Water Heating) - C&I Metered Multi-Family

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-PWREU  |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Installation of DHW pipe wraps.

#### BCR Measure IDs:

| Measure Name                                              | Core Initiative                           | BCR Measure ID |
|-----------------------------------------------------------|-------------------------------------------|----------------|
| Pipe Wrap (Water Heating), Electric (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a080        |
| Pipe Wrap (Water Heating), Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a060        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results where unit is a household with pipe wrap installed on hot water pipes.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

#### Savings for Pipe Wrap (Water Heating):

| Measure Name                                              | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|-----------------------------------------------------------|--------------|-------------|----------------|
| Pipe Wrap (Water Heating), Electric (Residential End Use) | 129          | 0.03        |                |
| Pipe Wrap (Water Heating), Gas (Residential End Use)      |              |             | 1.14           |

#### Baseline Efficiency:

The baseline efficiency case is the existing hot water equipment.

#### High Efficiency:

The high efficiency case includes pipe wrap.

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                                    | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Pipe Wrap (Water Heating) (Residential End Use) | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                              | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pipe Wrap (Water Heating), Electric (Residential End Use) | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Pipe Wrap (Water Heating), Gas (Residential End Use)      | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

The realization rates are set to 100% since deemed savings are based on evaluation results.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>4</sup>

**Impact Factors for Calculating Net Savings:**

Net to Gross factors are based on evaluation results.<sup>5</sup>

| Measure Name                                   | Core Initiative | PA  | FR   | SOP | SONP | NTG  |
|------------------------------------------------|-----------------|-----|------|-----|------|------|
| Pipe Wrap (Water Heating)(Residential End Use) | CI_RETRO        | All | 0.14 | 0.0 | 0.0  | 0.86 |

**Non-Energy Impacts:**

There are no non energy benefits identified for this measure.

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**Endnotes:**

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- 1 : The Cadmus Group (2015). Massachusetts Low Income Multifamily Impact Evaluation. [CADMUS 2015 Low Income Multifamily Impact Evaluation](#)
- 2 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 3 : GDS\_2007\_Measure\_Life\_Report\_Residential\_and\_CI\_Lighting\_and\_HVAC\_Measures [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 4 : Guidehouse (2020). Residential Baseline Study Phase 4 [2020 Guidehouse Residential Baseline Phase 4](#)
- 5 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

### 3.73. Hot Water - Pre-Rinse Spray Valve

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-PRSV   |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Retrofitting existing standard spray nozzles in locations where service water is supplied by natural gas fired hot water heater with new low flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.

#### BCR Measure IDs:

| Measure Name                              | Core Initiative                            | BCR Measure ID |
|-------------------------------------------|--------------------------------------------|----------------|
| Pre-Rinse Spray Valve, Electric (Turnkey) | C&I Existing Building Retrofit (CI_RETRO)  | EC2a147        |
| Pre-Rinse Spray Valve, Oil (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO)  | EC2a148        |
| Pre-Rinse Spray Valve, Propane (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO)  | EC2a149        |
| Pre-Rinse Spray Valve                     | C&I Existing Building Retrofit (CI_RETRO)  | GC2a023        |
| Pre-Rinse Spray Valve (Turnkey)           | C&I Existing Building Retrofit (CI_RETRO)  | GC2a044        |
| Pre-Rinse Spray Valve - Midstream         | C&I New & Replacement Equipment (CI_EQUIP) | GC2b044        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed and based on study results.<sup>1</sup> mmBTU savings for delivered fuel products assumed to be at a 1:1 relationship with already existing gas measure.

| Measure Name                    | $\Delta$ MMBtu | $\Delta$ kWh | $\Delta$ kW |
|---------------------------------|----------------|--------------|-------------|
| Pre-Rinse Spray Valve, Gas      | 11.4           |              |             |
| Pre-Rinse Spray Valve, Electric |                | 2300         | 0.50        |
| Pre-Rinse Spray Valve, Oil      | 11.4           |              |             |
| Pre-Rinse Spray Valve, Propane  | 11.4           |              |             |

**Baseline Efficiency:**

The baseline efficiency case is an existing efficiency spray valve.

**High Efficiency:**

The high efficiency case is a low flow pre-rinse spray valve with an average flow rate of 1.6 GPM.<sup>2</sup>

**Measure Life:**

The measure life is 3 years.<sup>3</sup>

| Measure Name          | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------|-----------------|-----|-----|-----|-----|-----|
| Pre-Rinse Spray Valve | CI_RETRO        | All | 8   | n/a | n/a | 3   |

**Other Resource Impacts:**

There are water savings of 6,410 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                    | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Pre-Rinse Spray Valve, Gas      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pre-Rinse Spray Valve, Electric | CI_RETRO        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.84             |
| Pre-Rinse Spray Valve, Oil      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Pre-Rinse Spray Valve, Propane  | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy, demand, and non-energy realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

## Impact Factors for Calculating Net Savings:

Values from 2021 C&I NTG study.<sup>6</sup>

| Measure Name                              | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Pre-Rinse Spray Valve, Gas                | CI_RETRO        | All | 0.369 | 0.000           | 0.032            | 0.663 |
| Pre-Rinse Spray Valve, Gas (Turnkey)      | CI_RETRO        | All | 0.285 | 0.000           | 0.000            | 0.715 |
| Pre-Rinse Spray Valve, Gas (Midstream)    | CI_EQUIP        | All | 0.373 | 0.026           | 0.191            | 0.844 |
| Pre-Rinse Spray Valve, Electric (Turnkey) | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Pre-Rinse Spray Valve, Oil (Turnkey)      | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Pre-Rinse Spray Valve, Propane (Turnkey)  | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |

## Non-Energy Impacts:

C&I values from 2021 C&I NEI study.<sup>6</sup>

| Measure Name               | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Pre-Rinse Spray Valve, Gas | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.36             |                       |

## Endnotes:

1 : DNV GL (2014). Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valves.

[DNVGL 2014 Impact Evaluation MA 2012 Gas Pre-Rinse Spray Valve](#)

2 : Per program administrator internal analysis.

4 : DNV GL (2014). Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valves.

[DNVGL 2014 Impact Evaluation MA 2012 Gas Pre-Rinse Spray Valve](#)

5 : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

### 3.74. Hot Water - Stand-Alone Thermostatic Valve

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-STV    |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Installation of a stand-alone thermostatic shut-off valve on standard-flow showerhead.

#### BCR Measure IDs:

| Measure Name                                    | Core Initiative                           | BCR Measure ID |
|-------------------------------------------------|-------------------------------------------|----------------|
| Thermostatic Shut-Off Valve, Electric (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a144        |
| Thermostatic Shut-Off Valve, Oil (Turnkey)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a145        |
| Thermostatic Shut-Off Valve, Propane (Turnkey)  | C&I Existing Building Retrofit (CI_RETRO) | EC2a146        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on engineering analysis.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup> MMBtu savings assumed to be at 1:1 relationship with already existing gas measure.

| Measure Name             | $\Delta$ kWh | $\Delta$ kW | $\Delta$ MMBtu |
|--------------------------|--------------|-------------|----------------|
| Standalone TSV, Electric | 69           | 0.01        |                |
| Standalone TSV, Gas      |              |             | 0.33           |
| Standalone TSV, Oil      |              |             | 0.33           |
| Standalone TSV, Propane  |              |             | 0.33           |

#### Baseline Efficiency:

The baseline efficiency is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

#### High Efficiency:

The high efficiency case is a standard flow showerhead (2.5 GPM) with the addition of a stand-alone thermostatic shut-off valve.

**Measure Life:**

The measure life is 10 years.<sup>3</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| Standalone TSV | CI_RETRO        | All | 10  | n/a | n/a | 10  |

**Other Resource Impacts:**

Annual per unit water savings of 558 gallons.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name             | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Standalone TSV, Electric | CI_RETRO        | All | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.31             | 0.84             |
| Standalone TSV, Gas      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Standalone TSV, Oil      | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Standalone TSV, Propane  | CI_RETRO        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy, demand, and non-energy realization rates.

**Coincidence Factors:**

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model which is developed based on the Residential Baseline Study.<sup>5</sup>

**Impact Factors for Calculating Net Savings:**

Net to gross values based on evaluated numbers.<sup>6</sup>

| Measure Name                       | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Standalone TSV, Electric (Turnkey) | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Standalone TSV, Oil (Turnkey)      | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Standalone TSV, Propane (Turnkey)  | CI_RETRO        | All | 0.077 | 0.013           | 0.004            | 0.940 |
| Standalone TSV, Gas (Turnkey)      | CI_RETRO        | All | 0.285 | 0.00            | 0.00             | 0.715 |

**Non-Energy Impacts:**

C&I values are from 2021 C&I NEI Study.<sup>7</sup>



| Measure Name        | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Standalone TSV, Gas | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.004            |                       |

**Endnotes:**

1 : National Grid (2014). Review of ShowerStart evolve

[National Grid 2014 ShowerStart Savings Final 2015-2-9](#)

2 : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

3 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15.

[GDS 2009 Natural Gas Energy Efficiency Potential in MA](#)

4 : National Grid (2014). Review of ShowerStart evolve

[National Grid 2014 ShowerStart Savings Final 2015-2-9](#)

5 : Guidehouse (2020). Residential Baseline Study Phase 4

[2020 Guidehouse Residential Baseline Phase 4](#)

7 : 2021 (NMR) C&I O&M and non-O&M NEI with Small Business Focus

### 3.75. Hot Water - Steam Trap

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-HVAC-ST   |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

Repair or replace malfunctioning steam traps.

#### BCR Measure IDs:

| Measure Name    | Core Initiative                           | BCR Measure ID |
|-----------------|-------------------------------------------|----------------|
| Steam Trap, Gas | C&I Existing Building Retrofit (CI_RETRO) | GC2a012        |

#### Algorithms for Calculating Primary Energy Impact:

Savings are deemed per unit.<sup>1</sup>

| Measure Name | ΔMMBtu |
|--------------|--------|
| Steam Trap   | 8.4    |

#### Baseline Efficiency:

The baseline efficiency case is a failed steam trap.

#### High Efficiency:

The high efficiency case is a repaired or replaced steam trap.

#### Measure Life:

The measure life is 6 years.<sup>2</sup>

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Steam Trap   | CI_RETRO        | All | 6   | n/a | n/a | 6   |

#### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Steam Trap   | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use 100% energy realization rate. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed.

**Impact Factors for Calculating Net Savings:**

Values from 2021 C&I NTG study.<sup>3</sup>

| Measure Name | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------|-----------------|-----|-------|-----------------|------------------|-------|
| Steam Trap   | CI_RETRO        | All | 0.369 | 0.00            | 0.032            | 0.663 |

**Non-Energy Impacts:**

NEIs are from 2021 Study.<sup>4</sup>

| Measure Name | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Steam Trap   | CI_RETRO        | All |                    |                      |                   |                     | \$ 0.08             |                       |

**Endnotes:**

**1** : Energy & Resource Solutions (2018). Two-Tier Steam Trap Savings Study. As a note, the 8.4 mmBTU savings value pertains to low pressure traps, [ERS 2018 Two Tier Steam Traps](#)

**2** : DNV GL (2015) Massachusetts 2013 Prescriptive Gas Impact Evaluation – Steam Trap Evaluation Phase I. [DNV GL 2015 Prescriptive Gas Steam Trap Phase 1](#)

### 3.76. Hot Water - Tankless Water Heater

|                     |                    |
|---------------------|--------------------|
| <b>Measure Code</b> | COM-WH-TWH         |
| <b>Market</b>       | Commercial         |
| <b>Program Type</b> | Replace on Burnout |
| <b>Category</b>     | Water Heating      |

#### Measure Description:

Tankless water heaters circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank .

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                            | BCR Measure ID |
|---------------------------------------------|--------------------------------------------|----------------|
| Water Heater, Instantaneous, Gas - Upstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b022        |

#### Algorithms for Calculating Primary Energy Impact:

Unit savings are per algorithm below and building specific.

$$\text{Annual Energy Savings (therms)} = \frac{365 \times \rho_w \times \text{Temperature Rise}}{100,000 \frac{\text{Btu}}{\text{therm}}} \times \left( \frac{1}{EF_{\text{installed}}} - \frac{1}{EF_{\text{baseline}}} \right) \times \text{GPD}$$

Temperature Rise = 80 (°F)

GPD = building specific per table below

EF<sub>Baseline</sub> = 0.71

EF<sub>Installed</sub> = 0.94

Water Density (ρ<sub>w</sub>) = 8.33

#### Building Type GPD Table<sup>1</sup>

| Building Type | HW Usage Category | GPD  |
|---------------|-------------------|------|
| Education     | Medium            | 222  |
| Healthcare    | High              | 1903 |
| Lodging       | Medium            | 222  |
| Mercantile    | Low               | 34   |
| Office        | Low               | 34   |
| Other         | Low               | 34   |

|                         |               |      |
|-------------------------|---------------|------|
| Religious Worship       | Low           | 34   |
| Warehouse               | Low           | 34   |
| Fast Food Restaurant    | Medium        | 222  |
| Full Service Restaurant | High          | 1903 |
| Grocery                 | Medium        | 222  |
| Gym                     | High          | 1903 |
| Laundromat              | Medium        | 222  |
| Multi-Family            | Multi-Family  | 64   |
| Public Safety           | Low           | 34   |
| Manufacturing           | Manufacturing | 78   |

**Baseline Efficiency:**

For on-demand tankless water heaters the baseline is based on evaluated results,  $EF = 0.71^2$ .

**High Efficiency:**

The high efficiency equipment is either a gas-fired instantaneous hot water heater with an Energy Factor of at least 0.94.

**Measure Life:**

The measure life is 20 years.<sup>3</sup>

| Measure Name                               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Tankless Water Heater, Gas 0.94 - Upstream | CI_EQUIP        | All | 20  | n/a | n/a | 20  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Tankless Water Heater, Gas 0.94 - Upstream | CI_EQUIP        | All | 1.00 | n/a             | 0.96             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

All PAs use a 96% non-energy realization rate.<sup>4</sup> The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

**Coincidence Factors:**

Not applicable for this measure since no electric savings are claimed

**Impact Factors for Calculating Net Savings:**

Values based on 2021 C&I Upstream HVAC NTG study<sup>5</sup>.

| Measure Name                          | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | 2022 NTG | 2023 NTG | 2024 NTG |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|----------|----------|----------|
| Tankless Water Heater, Gas - Upstream | CI_EQUIP        | All | 0.62 |                 |                  | 0.38     | 0.38     | 0.38     |

**Non-Energy Impacts:**

| Measure Name                      | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|-----------------------------------|-----------------|-----|-------------------|---------------------|
| Hot Water - Tankless Water Heater | CI_EQUIP        | All |                   | \$0.079             |

**Endnotes:**

- 1 : DNV GL, Inc (2019) Impact Evaluation of Commercial Water Heaters: Baseline Adjustment Memo Including Consumption Estimates. Table 3.
- 2 : DNV GL, Inc (2019). Impact Evaluation of Commercial Water Heaters: Baseline Adjustment Memo Including Water Consumption Estimates.
- 3 : Hewitt, D. Pratt, J. & Smith, G. (2005). Tankless Gas Water Heaters: Oregon Market Status. Prepared for the Energy Trust of Oregon [Hewitt Pratt Smith 2005 Tankless Gas Water Heaters](#)
- 4 : DNV GL, Inc (2019) Upstream Water Heater Deemed Savings Impact Evaluation & Market Quick Hit Study on Water Consumption for Tankless Water Heaters
- 5 : DNV GL (2018). C&I Upstream HVAC NTG Study.

### 3.77. Hot Water - Thermostatic Valve - C&I Metered Multi-Family

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-WH-TVREU  |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Water Heating |

#### Measure Description:

A stand-alone valve that may be used with existing showerhead. Thermostatic shut-off valve technology is known by the trademarked name ShowerStart™.

#### BCR Measure IDs:

| Measure Name                                                | Core Initiative                           | BCR Measure ID |
|-------------------------------------------------------------|-------------------------------------------|----------------|
| Thermostatic Shut-off Valve, Electric (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a077        |
| Thermostatic Shut-off Valve, Oil (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | EC2a078        |
| Thermostatic Shut-off Valve, Other (Residential End Use)    | C&I Existing Building Retrofit (CI_RETRO) | EC2a079        |
| Thermostatic Shut-off Valve, Gas (Residential End Use)      | C&I Existing Building Retrofit (CI_RETRO) | GC2a065        |

#### Algorithms for Calculating Primary Energy Impact:

The unit savings are deemed based on engineering analysis.<sup>1</sup> kW savings are calculated using the demand impact model.<sup>2</sup>

| Measure Name                                                | ΔkWh | ΔkW  | Δ MMBtu |
|-------------------------------------------------------------|------|------|---------|
| Thermostatic Shut-off Valve, Electric (Residential End Use) | 69   | 0.02 |         |
| Thermostatic Shut-off Valve, Gas (Residential End Use)      |      |      | 0.34    |
| Thermostatic Shut-off Valve, Oil (Residential End Use)      |      |      | 0.39    |
| Thermostatic Shut-off Valve, Other (Residential End Use)    |      |      | 0.34    |

**Baseline Efficiency:**

The Baseline Efficiency case is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.

**High Efficiency:**

The high efficiency case is a standard-flow showerhead (2.5 GPM) with the addition of the stand-alone thermostatic shut-off valve (the “Ladybug”).

**Measure Life:**

The measure life is 15 years.<sup>3</sup>

| Measure Name                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------|-----------------|-----|-----|-----|-----|-----|
| Thermostatic Shut-off Valve | CI_RETRO        | All | 15  | n/a | n/a | 15  |

**Other Resource Impacts:**

The annual water savings are 558 gallons per unit.<sup>4</sup>

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                          | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Thermostatic Shut-off Valve, Electric | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.31             | 0.84             |
| Thermostatic Shut-off Valve, Gas      | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Oil      | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |
| Thermostatic Shut-off Valve, Other    | CI_RETRO        | All | 1.00 | 1.00            | 1.00             | n/a              | n/a              | n/a              | n/a              |

**In-Service Rates:**

All installations have 100% in service rate.

**Realization Rates:**

Realization rates are set to 100% since savings are deemed

**Coincidence Factors:**

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.<sup>5</sup>



### Impact Factors for Calculating Net Savings:

Net to gross factors based on evaluation results.<sup>6</sup>

| Measure Name                                      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|---------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Thermostatic Shut-off Valve (Residential End Use) | CI_RETRO        | All | 0.14 | 0.0             | 0.0              | 0.86 |

### Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

### Endnotes:

- 1 : National Grid (2014). Review of ShowerStart evolve.  
[National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 2 : Navigant Consulting (2018). Demand Impact Model Update.  
[2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 3 : [2021 Guidehouse TRM Final Report](#)
- 4 : National Grid (2014). Review of ShowerStart evolve.  
[National Grid 2014 ShowerStart Savings Final 2015-2-9](#)
- 5 : Navigant Consulting (2018). Demand Impact Model Update.  
[2018 Navigant Baseline Loadshape Comprehensive Report](#)
- 6 : Guidehouse (2021). Residential Programs Net-to-Gross Research of RCD and Select Products Measures: Results Memo [2021 Guidehouse Res NTG Final Results Memo](#)

### 3.78. Hot Water - Volume Water Heater

|                     |                    |
|---------------------|--------------------|
| <b>Measure Code</b> | COM-WH-VWH         |
| <b>Market</b>       | Commercial         |
| <b>Program Type</b> | Replace on Burnout |
| <b>Category</b>     | Water Heating      |

#### Measure Description:

Installation of a high-efficiency gas-fired water heater.

#### BCR Measure IDs:

| Measure Name                         | Core Initiative                            | BCR Measure ID |
|--------------------------------------|--------------------------------------------|----------------|
| Water Heater, Volume, Gas - Upstream | C&I New & Replacement Equipment (CI_EQUIP) | GC2b027        |

#### Algorithms for Calculating Primary Energy Impact:

Savings values are tied to unit Mbtuh<sup>1</sup>.

| Measure Name                                | ΔMMBtu/Mbtuh |
|---------------------------------------------|--------------|
| Volume Water Heater, Gas 0.94 TE - Upstream | 0.460        |

#### Baseline Efficiency:

The assumed baseline is per evaluation results, 83% TE volume water heater<sup>2</sup>.

#### High Efficiency:

The high efficiency case is a volume water heater with a 94% TE.

#### Measure Life:

The measure life is 15 years.<sup>3</sup>

| Measure Name                                | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Volume Water Heater, Gas 0.94 TE - Upstream | CI_EQUIP        | All | 15  | n/a | n/a | 15  |

#### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Volume Water Heater, Gas 0.94 TE - Upstream | CI_EQUIP        | All | 1.00 | n/a             | 1.00             | n/a              | n/a              | n/a              | n/a              |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

All PAs use a 100% realization rate<sup>4</sup>. The summer and winter peak realization rates are not applicable for this measure since there are no electric savings claimed.

### Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

### Impact Factors for Calculating Net Savings:

Values based on 2021 C&I Upstream HVAC NTG study<sup>5</sup>.

| Measure Name                        | Core Initiative | PA  | FR   | 2022 NTG | 2023 NTG | 2024 NTG |
|-------------------------------------|-----------------|-----|------|----------|----------|----------|
| Volume Water Heater, Gas - Upstream | CI_EQUIP        | All | 0.56 | 0.44     | 0.44     | 0.44     |

### Non-Energy Impacts:

| Measure Name                    | Core Initiative | PA  | Annual \$ per kWh | Annual \$ per Therm |
|---------------------------------|-----------------|-----|-------------------|---------------------|
| Hot Water - Volume Water Heater | CI_EQUIP        | All |                   | \$0.079             |

### Endnotes:

- 1 : DNV GL, Inc (2019). Impact Evaluation of Commercial Water Heaters: Baseline Adjustment Memo Including Water Consumption Estimates. Table 5.
- 2 : DNV GL, Inc (2019). Impact Evaluation of Commercial Water Heaters: Baseline Adjustment Memo Including Water Consumption Estimates.
- 3 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts; Appendix A-2. [GDS 2007 Measure Life Report Residential and CI Lighting and HVAC Measures](#)
- 4 : DNV GL, Inc (2019). Impact Evaluation of Commercial Water Heaters: Baseline Adjustment Memo Including Water Consumption Estimates. NOTE - realization rate changed b/w 2019 and 2020 as net impacts have been folded into deemed savings values beginning in 2020.
- 5 : DNV GL (2018). C&I Upstream HVAC NTG Study.

### 3.79. Lighting - C&I Metered Multi-Family

|                     |            |
|---------------------|------------|
| <b>Measure Code</b> | COM-L-FREU |
| <b>Market</b>       | Commercial |
| <b>Program Type</b> | Retrofit   |
| <b>Category</b>     | Lighting   |

#### Measure Description:

Removal of existing inefficient fixtures with the installation of new efficient fixtures.

#### BCR Measure IDs:

| Measure Name                                                    | Core Initiative                              | BCR Measure ID |
|-----------------------------------------------------------------|----------------------------------------------|----------------|
| LED Fixture, Indoor Common Area<br>(Residential End Use)        | C&I Existing Building Retrofit<br>(CI_RETRO) | EC2a095        |
| LED Fixture, Linear Indoor Common Area<br>(Residential End Use) | C&I Existing Building Retrofit<br>(CI_RETRO) | EC2a096        |
| LED Fixture, Outdoor Common Area<br>(Residential End Use)       | C&I Existing Building Retrofit<br>(CI_RETRO) | EC2a097        |

#### Algorithms for Calculating Primary Energy Impact:

Although these measures are reported within the C&I sector in order to follow Department directives regarding sector cross-subsidization, these measures are delivered as part of the Residential Coordination Delivery program, and evaluated as such. Therefore, please refer to the residential TRM entry for the savings calculations for these measures: "Lighting - Residential".

### 3.80. Lighting - Controls

|                     |            |
|---------------------|------------|
| <b>Measure Code</b> | COM-L-LC   |
| <b>Market</b>       | Commercial |
| <b>Program Type</b> | Retrofit   |
| <b>Category</b>     | Lighting   |

#### Measure Description:

This measure promotes the installation of lighting controls in both lost-opportunity and retrofit applications. Promoted technologies include occupancy sensors and daylight dimming controls.

#### BCR Measure IDs:

| Measure Name                           | Core Initiative                                  | BCR Measure ID |
|----------------------------------------|--------------------------------------------------|----------------|
| Lighting Controls - Daylight Dimming   | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a020        |
| Lighting Controls - Occupancy Sensor   | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a021        |
| Lighting Controls - Dual Sensor/Other  | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a022        |
| Lighting Controls - Exterior           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a023        |
| Lighting Controls - Daylight Dimming   | C&I Existing Building Retrofit (CI_RETRO)        | EC2a015        |
| Lighting Controls - Occupancy Sensor   | C&I Existing Building Retrofit (CI_RETRO)        | EC2a016        |
| Lighting Controls - Dual Sensor/Other  | C&I Existing Building Retrofit (CI_RETRO)        | EC2a017        |
| Lighting Controls - Exterior           | C&I Existing Building Retrofit (CI_RETRO)        | EC2a018        |
| Lighting Controls - Interior (Turnkey) | C&I Existing Building Retrofit (CI_RETRO)        | EC2a050        |
| Lighting Controls - Exterior (Turnkey) | C&I Existing Building Retrofit (CI_RETRO)        | EC2a051        |
| Lighting Controls - Daylight Dimming   | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b019        |

|                                       |                                            |         |
|---------------------------------------|--------------------------------------------|---------|
| Lighting Controls - Occupancy Sensor  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b020 |
| Lighting Controls - Dual Sensor/Other | C&I New & Replacement Equipment (CI_EQUIP) | EC2b021 |
| Lighting Controls - Exterior          | C&I New & Replacement Equipment (CI_EQUIP) | EC2b022 |

### Algorithms for Calculating Primary Energy Impact:

*C&I New Buildings & Major Renovations, C&I Initial Purchase & End of Useful Life, C&I Existing Building Retrofit:*

$$\Delta kWh = \text{ControlledkW} * \text{Hours}_{\text{base}} * (\%_{\text{sav}})$$

$$\Delta kW = (\text{ControlledkW})$$

*C&I Small Business:*

$$\Delta kWh = (\text{ControlledkW}) (\text{Hours}_{\text{base}} - \text{Hours}_{\text{see}})$$

$$\Delta kW = (\text{ControlledkW})$$

Where:

Controlled kW = Controlled fixture wattage

%<sub>sav</sub> = Percentage of kWh that is saved by utilizing the control measure.

Hours<sub>BASE</sub> = Total annual hours that the connected Watts operated in the pre-retrofit case (retrofit installations) or would have operated with code-compliance controls (new construction installations).

Hours<sub>SEE</sub> = Annual hours that the connect Watts operate with controls implemented

Savings factors are deemed based on study results or engineering calculated.<sup>1</sup>

| Measure Name                                                                   | % Savings Factor |
|--------------------------------------------------------------------------------|------------------|
| Lighting Controls – Daylighting Dimming                                        | 0.28             |
| Lighting Controls – Occupancy Sensor                                           | 0.24             |
| Lighting Controls - Integral Dual Sensor                                       | 0.30             |
| Lighting Controls - Integral Dual Sensors w Adaptive, Network-Capable Controls | 0.35             |
| Lighting Controls - Exterior Photocell                                         | 0.50             |

### Baseline Efficiency:

The baseline efficiency case assumes no controls (retrofit) or code-compliant controls (new construction).

### High Efficiency:

The high efficiency case involves lighting fixtures connected to controls that reduce the pre-retrofit or baseline hours of operation.

### Measure Life:

Measure life for retrofit control measures is 9 years and for lost opportunity control measures is 10 years.<sup>2</sup>

| Measure Name      | Core Initiative      | PA  | EUL | OYF | RUL | AML |
|-------------------|----------------------|-----|-----|-----|-----|-----|
| Lighting Controls | CI_RETRO             | All | 9   | n/a | n/a | 9   |
| Lighting Controls | CI_NB&MR<br>CI_EQUIP | All | 10  | n/a | n/a | 10  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                            | Core Initiative                  | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------|----------------------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Lighting Controls – Interior (Turnkey)  | CI_RETRO                         | All | 1.00 | 0.42            | 0.42             | 0.92             | 0.92             | 0.18             | 0.13             |
| Lighting Controls – Exterior (Turnkey)  | CI_RETRO                         | All | 1.00 | 0.42            | 0.42             | 0.92             | 0.92             | 1.00             | 0.00             |
| Lighting Controls – Daylighting Dimming | CI_RETRO<br>CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.03            | 1.03             | 0.94             | 0.94             | 0.15             | 0.13             |
| Lighting Controls – Occupancy Sensor    | CI_RETRO<br>CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.03            | 1.03             | 0.94             | 0.94             | 0.15             | 0.13             |
| Lighting Controls – Dual Sensor/Other   | CI_RETRO<br>CI_NB&MR<br>CI_EQUIP | All | 1.00 | 1.03            | 1.03             | 0.94             | 0.94             | 0.15             | 0.13             |
| Lighting Controls – Exterior            | CI_RETRO<br>CI_NB&MR<br>CI_EQUIP | All | 1.00 | 0.72            | 0.72             | 0.94             | 0.94             | 1.00             | 0.00             |

### In-Service Rates:

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Large C&I: energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs. Demand RR is the connected demand RR; Energy RR includes

- connected kWh RR, hours of use RR, and HVAC Interactive adjustment.<sup>3</sup>
- Small C&I Existing Building Retrofit: RRs from statewide Pre/Post Occupancy Sensor study.<sup>4</sup>

**Coincidence Factors:**

- Large C&I: CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.<sup>5</sup>
- C&I Small Business: CFs from statewide Pre/Post Occupancy Sensor study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

Net-to-gross values are deemed based on study results.<sup>7 8</sup>

| Measure Name            | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Lighting Controls (All) | CI_NB&MR        | All | 0.583 | 0.227           | n/a              | 0.644 |
| Lighting Controls (All) | CI_RETRO        | All | 0.135 | 0.053           | 0.018            | 0.936 |
| Lighting Controls (All) | CI_EQUIP        | All | 0.225 | 0.085           | 0.000            | 0.860 |

**Non-Energy Impacts:**

| Measure Name            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Lighting Controls (All) | CI_NB&MR        | All |                    |                      | \$0.106           |                     |                     |                       |
| Lighting Controls (All) | CI_RETRO        | All |                    |                      | \$0.127           |                     |                     |                       |
| Lighting Controls (All) | CI_EQUIP        | All |                    |                      | \$0.106           |                     |                     |                       |

**Endnotes:**

- 1** : DNV KEMA (2014) Retrofit Lighting Controls Measures Summary of Findings FINAL REPORT. Report applies to daylight dimming and occupancy sensor controls. Dual sensor control savings factors are engineering calculated. Exterior controls factor only apply to On/Off Photocells for lighting systems that operate on 24 hours per day, 7 days per week (8,760 hours annually). Exterior controls with bi-level occupancy, dimming functions, or any other advanced/networked controls would receive a
- 2** : ERS (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)
- 3** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. [DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)
- 4** : The Cadmus Group (2012). Final Report, Small Business Direct Install Program: Pre/Post Occupancy



Sensor Study. [CADMUS 2012 SBDI PrePostLightingControl Final](#)

**5** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.

[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**6** : The Cadmus Group (2012). Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study. [CADMUS 2012 SBDI PrePostLightingControl Final](#)

**7** : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)

**8** : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)

### 3.81. Lighting - Freezer/Cooler LED

|                     |             |
|---------------------|-------------|
| <b>Measure Code</b> | COM-L-FCLED |
| <b>Market</b>       | Commercial  |
| <b>Program Type</b> | Retrofit    |
| <b>Category</b>     | Lighting    |

#### Measure Description:

Installation of LED lighting in freezer and/or cooler cases. The LED lighting consumes less energy, and results in less waste heat which reduces the cooling/freezing load.

#### BCR Measure IDs:

| Measure Name                  | Core Initiative                           | BCR Measure ID |
|-------------------------------|-------------------------------------------|----------------|
| Freezer/Cooler LEDs           | C&I Existing Building Retrofit (CI_RETRO) | EC2a030        |
| Freezer/Cooler LEDs (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a152        |

#### Algorithms for Calculating Primary Energy Impact:

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

$$\Delta kWh_{LED} = \text{Summation of } i=1 \text{ to } n (\text{Count}_i * kW_i * \text{Hours}_i)_{BASE} - \text{Summation of } i=1 \text{ to } m (\text{Count}_j * kW_j * \text{Hours}_j)_{LED}$$

$$\Delta kWh_{heat} = \Delta kWh_{LED} * 0.28 * \text{Eff}_{RS}$$

$$\Delta kW = \Delta kWh / \text{Hours}_j$$

Where:

$\Delta kWh_{LED}$  = Reduction in lighting energy

$\Delta kWh_{Heat}$  = Reduction in refrigeration energy due to reduced heat loss from the lighting fixtures

N = Total number of lighting fixture types in the pre-retrofit case

M = Total number of lighting fixture types in the post-retrofit case

$\text{Count}_i$  = Quantity of type i fixtures in the pre-retrofit case

$kW_i$  = Power demand of pre-retrofit lighting fixture type i (kW/fixture)

$\text{Hours}_i$  = Pre-retrofit annual operating hours of fixture type i

$\text{Count}_j$  = Quantity of type j fixtures in the pre-retrofit case

$kW_j$  = Power demand of lighting fixture type j (kW/fixture)

$\text{Hours}_j$  = Post-retrofit annual operating hours of fixture type j

0.28 = Unit conversion between kW and tons calculated as 3,413 Btuh/kW divided by 12,000 Btuh/ton

$\text{Eff}_{RS}$  = Efficiency of typical refrigeration system: 1.6 kW/ton for C&I Small Business; 1.9 kW/ton for Large C&I<sup>1</sup>

#### Baseline Efficiency:

The baseline efficiency case is the existing lighting fixtures in the cooler or freezer cases.

### High Efficiency:

The high efficiency case is the installation of LED lighting fixtures on the cooler or freezer cases, replacing the existing lighting fixtures.

### Measure Life:

The measure life is per the table below and reflects the evaluated, ambient linear measure life category.<sup>2</sup>

| Measure Name        | Core Initiative | PA  | 2022 | 2023 | 2024 |
|---------------------|-----------------|-----|------|------|------|
| Freezer/Cooler LEDs | CI_RETRO        | All | 10   | 10   | 10   |

### 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 <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Freezer/Cooler LEDs | Retrofit        | All | 1.00 | 0.94            | 1.00             | 1.01             | 1.01             | 0.99             | 1.00             |

### In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

### Realization Rates:

All PAs energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.<sup>3</sup>

### Coincidence Factors:

All PAs CFs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.<sup>4</sup>

### Impact Factors for Calculating Net Savings:

Net-to-Gross is based on study results.<sup>5</sup>

| Measure Name        | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|---------------------|-----------------|-----|------|-----------------|------------------|-------|
| Freezer/Cooler LEDs | CI_RETRO        | All | 0.23 | 0.001           | 0.016            | 0.936 |

### Non-Energy Impacts:

There are no non-energy impacts identified for this measure.

### Endnotes:

1 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.

[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

2 : DNV GL, (2020). C&I Linear Lighting Saturation & Market Model Adjusted Measure Lives

**3** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations

[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**4** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations

[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**5** : NMR (2018). Massachusetts Sponsor's Commercial and Industrial Free-ridership and Spillover Study.

[2018 NMR CI FR-SO Report](#)

### 3.82. Lighting - Performance Lighting

|                     |            |
|---------------------|------------|
| <b>Measure Code</b> | COM-L-ALD  |
| <b>Market</b>       | Commercial |
| <b>Program Type</b> | Retrofit   |
| <b>Category</b>     | Lighting   |

#### Measure Description:

Advanced lighting design refers to the implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction situation. Advanced lighting design uses techniques like maximizing task lighting and efficient fixtures to create a system of optimal energy efficiency and functionality.

#### BCR Measure IDs:

| Measure Name                                  | Core Initiative                                  | BCR Measure ID |
|-----------------------------------------------|--------------------------------------------------|----------------|
| Performance Lighting (Interior)               | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a014        |
| Performance Lighting (Exterior)               | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a015        |
| Performance Lighting (Interior with Controls) | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a016        |
| Performance Lighting (Exterior with Controls) | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a017        |
| Performance Lighting (Interior)               | C&I Existing Building Retrofit (CI_RETRO)        | EC2a009        |
| Performance Lighting (Exterior)               | C&I Existing Building Retrofit (CI_RETRO)        | EC2a010        |
| Performance Lighting (Interior with Controls) | C&I Existing Building Retrofit (CI_RETRO)        | EC2a011        |
| Performance Lighting (Exterior with Controls) | C&I Existing Building Retrofit (CI_RETRO)        | EC2a012        |
| Performance Lighting (Interior)               | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b013        |
| Performance Lighting (Exterior)               | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b014        |

|                                               |                                            |         |
|-----------------------------------------------|--------------------------------------------|---------|
| Performance Lighting (Interior with Controls) | C&I New & Replacement Equipment (CI_EQUIP) | EC2b015 |
| Performance Lighting (Exterior with Controls) | C&I New & Replacement Equipment (CI_EQUIP) | EC2b016 |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = \sum_{i=1}^n (LPD_{Base,i} - \text{Controlled} \times LPD_{Proposed,i} \times 0.8) \times Area_i \times Hours_i \times 1/1000$$

$$\Delta kW_{Fixture} = \sum_{i=1}^n LPD_{Base,i} \times Area_i \times 1/1000 - LPD_{Proposed,i} \times Area_i \times 1/1000$$

$$\Delta kW_{Controlled} = \sum_{i=1}^n LPD_{Proposed,i} \times Area_i \times 0.8 \times 1/1000$$

Where:

n = Total number of spaces or 1 for Building Area Method

LPD<sub>Base,i</sub> = Baseline lighting power density for building or space type i (Watts/ft<sup>2</sup>)

Area<sub>i</sub> = Area of building or space i (ft<sup>2</sup>)

Hours<sub>i</sub> = Annual hours of operation of the lighting equipment for space type i

LPD<sub>Proposed,i</sub> = Proposed lighting power density for building or space type i (Watts/ft<sup>2</sup>)

Controlled = Min % of controlled lighting above required amounts for each tier

1000 = Conversion factor: 1000 watts per 1 kW

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates.

Note on Performance Lighting tiers: Performance Lighting has 3 tiers, for New Buildings & Major Renovations the min percentage of controlled lighting above required amounts at 0% for tier 1, 20% for tier 2, and 30% for tier 3. All other Performance Lighting programs have min percentage of controlled lighting above required amounts of 15% for tier 1, 35% for tier 2, and 45% for tier 3.

### Baseline Efficiency:

The Baseline Efficiency assumes compliance with lighting power density requirements as mandated by Massachusetts State Building Code, which currently reflects IECC 2012. IECC 2012 offers two compliance paths, the Building Area Method and Space-by-Space Method.

### High Efficiency:

The high efficiency scenario assumes lighting systems that achieve lighting power densities below those required by Massachusetts State Building Code. Actual site lighting power densities should be determined on a case-by-case basis. Please refer to the current year application form for minimum percentage better than code efficiency requirements.

**Measure Life:**

Measures lives are deemed based on study results for 2022.<sup>1</sup> 2023 and 2024 Measure lives are estimated based off of historical trajectory for planning purposes.

| Application                                   | Core Initiative      | PA  | 2022 | 2023 | 2024 |
|-----------------------------------------------|----------------------|-----|------|------|------|
| Ambient Linear TLED                           | CI_EQUIP<br>CI_RETRO | All | 7    | 6    | 5    |
| Ambient Linear Fixtures                       | CI_EQUIP<br>CI_RETRO | All | 7    | 6    | 5    |
| High/Low Bay Lamps                            | CI_EQUIP<br>CI_RETRO | All | 8    | 7    | 6    |
| High/Low Bay TLED                             | CI_EQUIP<br>CI_RETRO | All | 8    | 7    | 6    |
| High/Low Bay Fixtures                         | CI_EQUIP<br>CI_RETRO | All | 8    | 7    | 6    |
| Exterior/Outdoor Lamps                        | CI_EQUIP<br>CI_RETRO | All | 6    | 5    | 4    |
| Exterior/Outdoor TLED                         | CI_EQUIP<br>CI_RETRO | All | 6    | 5    | 4    |
| Exterior/Outdoor Fixtures                     | CI_EQUIP<br>CI_RETRO | All | 6    | 5    | 4    |
| A-Lamps                                       | CI_EQUIP<br>CI_RETRO | All | 2    | 1    | 1    |
| Decoratives                                   | CI_EQUIP<br>CI_RETRO | All | 2    | 1    | 1    |
| Downlights/Track                              | CI_EQUIP<br>CI_RETRO | All | 2    | 1    | 1    |
| Performance Lighting (Interior)               | CI_NB&MR             | All | 15   | 15   | 15   |
| Performance Lighting (Exterior)               | CI_NB&MR             | All | 15   | 15   | 15   |
| Performance Lighting (Interior with Controls) | CI_NB&MR             | All | 15   | 15   | 15   |
| Performance Lighting (Exterior with Controls) | CI_NB&MR             | All | 15   | 15   | 15   |

The CI\_EQUIP and CI\_RETRO measure lives above are to be applied by PAs to the measures in their tracking system. PAs' lighting BCR line items will be a weighted average of the evaluated measure lives of the underlying lighting products for that category. For CI\_NB&MR, the measure lives remain unchanged at 15 years.

**Other Resource Impacts:**

Heating penalties are from the 12-month lighting logger study performed on lighting systems.<sup>2</sup>

| Measure Name                                | Core Initiative      | PA  | MMBtu/kWh |
|---------------------------------------------|----------------------|-----|-----------|
| Performance Lighting (Interior)             | CI_NB&MR<br>CI_EQUIP | All | -0.000175 |
| Performance Lighting (Exterior)             | CI_NB&MR<br>CI_EQUIP | All | n/a       |
| Performance Lighting (Interior w/ Controls) | CI_NB&MR<br>CI_EQUIP | All | -0.000175 |
| Performance Lighting (Exterior w/ Controls) | CI_NB&MR<br>CI_EQUIP | All | n/a       |
| Performance Lighting (Interior)             | CI_RETRO             | All | -0.000175 |
| Performance Lighting (Exterior)             | CI_RETRO             | All | n/a       |
| Performance Lighting (Interior w/ Controls) | CI_RETRO             | All | -0.000175 |
| Performance Lighting (Exterior w/ Controls) | CI_RETRO             | All | n/a       |

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                        | Core Initiative                  | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------------|----------------------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Performance Lighting (Interior w/ and w/o Controls) | CI_NB&MR<br>CI_EQUIP<br>CI_RETRO | All | 1.00 | 1.19            | 1.19             | 1.01             | 1.01             | 0.83             | 0.65             |
| Performance Lighting (Exterior w/ and w/o Controls) | CI_NB&MR<br>CI_EQUIP<br>CI_RETRO | All | 1.00 | 1.12            | 1.12             | 1.01             | 1.01             | 0.00             | 1.00             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

Energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs. Demand RR is the connected demand RR; energy RR includes connected kW RR, hours of use RR and HVAC Interactive adjustment.<sup>3</sup>

**Coincidence Factors:**

All CFs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting program<sup>4</sup>



### Impact Factors for Calculating Net Savings:

Factors are deemed based on study results.<sup>5</sup>

Net-to-gross values for the New Buildings and Major Renovations Core Initiative are based on study results.<sup>6</sup>

| Measure Name               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------|-----------------|-----|------|-----------------|------------------|------|
| Performance Lighting (All) | CI_NB&MR        | All | 0.58 | 0.22            | 0.00             | 0.64 |
| Performance Lighting (All) | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |
| Performance Lighting (All) | CI_EQUIP        | All | 0.23 | 0.09            | 0.00             | 0.86 |

### Non-Energy Impacts:

New Construction non-energy benefits are from the 2016 NEI study.<sup>6</sup> Retrofit non-energy benefits are from the 2012 NEI study.<sup>7</sup>

| Measure Name         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Performance Lighting | CI_NB&MR        | All |                    |                      | \$0.106           |                     |                     |                       |
| Performance Lighting | CI_RETRO        | All |                    |                      | \$0.127           |                     |                     |                       |
| Performance Lighting | CI_EQUIP        | All |                    |                      | \$0.106           |                     |                     |                       |

### Endnotes:

- 1 : DNV GL, (2021). C&I Linear Lighting Saturation & Market Model Adjusted Measure Lives
- 2 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. [DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)
- 3 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. [DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)
- 4 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. [DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)
- 5 : NMR (2018). Massachusetts Sponsor's Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)
- 6 : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)
- 6 : Tetra Tech (2016). C&I New Construction Non-Energy Impacts Study. [DNVGL 2016 CI NC NEI](#)
- 7 : Tetra Tech (2012). C&I Retrofit Non-Energy Impacts Study [TETRATECH 2012 MA CI NEI REPORT](#)

### 3.83. Lighting - System

|                     |            |
|---------------------|------------|
| <b>Measure Code</b> | COM-L-LS   |
| <b>Market</b>       | Commercial |
| <b>Program Type</b> | Retrofit   |
| <b>Category</b>     | Lighting   |

#### Measure Description:

This measure promotes the installation of efficient lighting including, but not limited to, efficient fluorescent lamps, ballasts, and fixtures, and solid state lighting.

#### BCR Measure IDs:

| Measure Name                          | Core Initiative                                  | BCR Measure ID |
|---------------------------------------|--------------------------------------------------|----------------|
| Lighting Systems - Interior           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a018        |
| Lighting Systems - Exterior           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a019        |
| Lighting Systems Interior             | C&I Existing Building Retrofit (CI_RETRO)        | EC2a013        |
| Lighting Systems Exterior             | C&I Existing Building Retrofit (CI_RETRO)        | EC2a014        |
| Lighting Systems - Interior (Turnkey) | C&I Existing Building Retrofit (CI_RETRO)        | EC2a048        |
| Lighting Systems - Exterior (Turnkey) | C&I Existing Building Retrofit (CI_RETRO)        | EC2a049        |
| Lighting Systems - Interior           | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b017        |
| Lighting Systems - Exterior           | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b018        |
| Midstream - LED Screw In              | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b059        |
| Midstream - LED Stairwell Kit         | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b060        |
| Midstream - LED Linear Lamp (TLED)    | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b058        |

|                                                  |                                            |         |
|--------------------------------------------------|--------------------------------------------|---------|
| Midstream - LED Linear Lamp (TLED) with Controls | C&I New & Replacement Equipment (CI_EQUIP) | EC2b099 |
| Midstream - LED Linear Fixture                   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b088 |
| Midstream - LED Linear Fixture with Controls     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b061 |
| Midstream - High Bay / Low Bay                   | C&I New & Replacement Equipment (CI_EQUIP) | EC2b062 |
| Midstream - High Bay / Low Bay with Controls     | C&I New & Replacement Equipment (CI_EQUIP) | EC2b096 |
| Midstream - LED Exterior                         | C&I New & Replacement Equipment (CI_EQUIP) | EC2b063 |
| Midstream - LED Exterior with Controls           | C&I New & Replacement Equipment (CI_EQUIP) | EC2b100 |

### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (\text{Summation } i=1 \text{ to } n(\text{Count}_i * \text{Watts}_i / 1000))_{BASE} - \text{Summation } j=1 \text{ to } n(\text{Count}_j * \text{Watts}_j / 1000)_{EE} \text{ (Hours)}$$

$$\Delta kW = \text{Summation } i=1 \text{ to } n(\text{Count}_i * \text{Watts}_i / 1000)_{BASE} - \text{Summation } j=1 \text{ to } n(\text{Count}_j * \text{Watts}_j / 1000)_{EE}$$

Where:

n = Total number of fixture types in baseline or pre-retrofit case

m = Total number of installed fixture types

Count<sub>i</sub> = Quantity of existing fixtures of type i (for lost-opportunity, Count<sub>i</sub> = Count<sub>j</sub>).

Watts<sub>i</sub> = Existing fixture or baseline wattage for fixture type i

Count<sub>j</sub> = Quantity of efficient fixtures of type j.

Watts<sub>j</sub> = Efficient fixture wattage for fixture type j.

1000 = Conversion factor: 1000 watts per kW.

Hours = Lighting annual hours of operation.

Upstream lighting measures will calculate gross energy savings in the 2022-2024 term using annual hours of operation defined for the particular building type the lamp was installed. These categories and hours of use are defined in the table below. For all downstream measures the annual hours of operation are sight specific or per the downstream table below.

### Upstream Hours of Use By Building Type<sup>1</sup>

| Building Type        | Hours of Use |
|----------------------|--------------|
| College & University | 4,132        |
| Grocery/Food Sales   | 5,920        |
| Hospital             | 5,601        |

|                          |       |
|--------------------------|-------|
| Industrial/Manufacturing | 5,229 |
| K-12 School              | 2,902 |
| Lodging                  | 4,194 |
| Medical Office           | 3,673 |
| Office Building          | 4,171 |
| Other                    | 4,141 |
| Restaurant/Food Service  | 4,891 |
| Retail                   | 4,957 |
| Warehouse and Storage    | 6,512 |
| Parking Garages          | 8,760 |

**Downstream Hours of Use By Building Type<sup>2</sup>**

| <b>Building Type</b>                 | <b>Hours of Use</b> |
|--------------------------------------|---------------------|
| Auto Related                         | 4,336               |
| Daycare                              | 2,788               |
| Education - School                   | 2,788               |
| Education - College/University       | 4,839               |
| Grocery                              | 5,468               |
| Health/Medical - Clinic              | 3,673               |
| Hospital                             | 5,413               |
| Industrial Manufacturing - 1 Shift   | 2,857               |
| Industrial Manufacturing - 2 Shifts  | 4,730               |
| Industrial Manufacturing - 3 Shifts  | 6,631               |
| Library                              | 2,788               |
| Lodging - Guest Room                 | 914                 |
| Lodging - Common Space               | 4,026               |
| Multi-Family High-Rise - Common Area | 4,336               |
| Nursing Home                         | 4,026               |
| Office                               | 4,181               |
| Parking Garage                       | 6,552               |

|                                     |       |
|-------------------------------------|-------|
| Public Order & Safety               | 4,336 |
| Public Assembly - 1 Shift           | 2,610 |
| Public Service - Non Food           | 3,425 |
| Restaurant                          | 5,018 |
| Retail                              | 4,939 |
| Religious Worship/Church            | 1,810 |
| Storage - Conditioned/Unconditioned | 3,420 |
| Warehouse - Inactive Storage        | 2,316 |
| Warehouse - Distribution Center     | 6,512 |

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates.

### Baseline Efficiency:

For retrofit installations, the baseline efficiency case is project-specific and is determined using actual fixture counts from the existing space. For lost opportunity installations, the baseline efficiency case is determined using assumed baseline wattages for each of the installed fixtures unless baseline assumptions have been evaluated.

### High Efficiency:

For both new construction and retrofit installations, the high efficiency case is project-specific and is determined using actual fixture counts for the project and the Mass Save Wattage Tables.

### Measure Life:

Measure lives are deemed based on study results for 2022.<sup>2</sup> 2023 and 2024 Measure lives are estimated based off of historical trajectory for planning purposes.

| Application             | Core Initiative      | PA  | 2022 | 2023 | 2024 |
|-------------------------|----------------------|-----|------|------|------|
| Ambient Linear TLED     | CI_EQUIP<br>CI_RETRO | All | 7    | 6    | 5    |
| Ambient Linear Fixtures | CI_EQUIP<br>CI_RETRO | All | 7    | 6    | 5    |
| High/Low Bay Lamps      | CI_EQUIP<br>CI_RETRO | All | 8    | 7    | 6    |
| High/Low Bay TLED       | CI_EQUIP<br>CI_RETRO | All | 8    | 7    | 6    |

|                             |                      |     |    |    |    |
|-----------------------------|----------------------|-----|----|----|----|
| High/Low Bay Fixtures       | CI_EQUIP<br>CI_RETRO | All | 8  | 7  | 6  |
| Exterior/Outdoor Lamps      | CI_EQUIP<br>CI_RETRO | All | 6  | 5  | 4  |
| Exterior/Outdoor TLED       | CI_EQUIP<br>CI_RETRO | All | 6  | 5  | 4  |
| Exterior/Outdoor Fixtures   | CI_EQUIP<br>CI_RETRO | All | 6  | 5  | 4  |
| A-Lamps                     | CI_EQUIP<br>CI_RETRO | All | 2  | 1  | 1  |
| Decoratives                 | CI_EQUIP<br>CI_RETRO | All | 2  | 1  | 1  |
| Downlights/Track            | CI_EQUIP<br>CI_RETRO | All | 2  | 1  | 1  |
| Lighting Systems - Interior | CI_NB&MR             | All | 15 | 15 | 15 |
| Lighting Systems - Exterior | CI_NB&MR             | All | 15 | 15 | 15 |

The CI\_EQUIP and CI\_RETRO measure lives above are to be applied by PAs to the measures in their tracking system. PAs' lighting BCR line items will be a weighted average of the evaluated measure lives of the underlying lighting products for that category. For CI\_NB&MR, the measure lives remain unchanged at 15 years.

### Other Resource Impacts:

There are fossil fuel heating penalties associated with lighting as follows.

| Measure Name                               | Core Initiative                | PA  | MMBtu/kWh |
|--------------------------------------------|--------------------------------|-----|-----------|
| Lighting Systems - Interior                | CI_NB&MR<br>CI_EQUIP, CI_RETRO | All | -0.000691 |
| Lighting Systems - Exterior                | CI_NB&MR<br>CI_EQUIP, CI_RETRO | All | n/a       |
| Lighting Systems – Interior (Turnkey)      | CI_RETRO                       | All | -0.00090  |
| Lighting Systems – Exterior (Turnkey)      | CI_RETRO                       | All | n/a       |
| Lighting Upstream – LED Linear             | CI_EQUIP                       | All | -0.000162 |
| Lighting Upstream – LED Screw In           | CI_EQUIP                       | All | -0.000329 |
| Lighting Upstream – LED Stairwell          | CI_EQUIP                       | All | n/a       |
| Lighting Upstream – LED Linear w/ Controls | CI_EQUIP                       | All | -0.000162 |
| Lighting Upstream – High/Low Bay           | CI_EQUIP                       | All | -0.000329 |

|                                                             |          |     |           |
|-------------------------------------------------------------|----------|-----|-----------|
| Lighting Upstream – LED Exterior                            | CI_EQUIP | All | n/a       |
| Lighting Upstream - High/Low Bay w/Controls                 | CI_EQUIP | All | -0.000329 |
| Lighting Upstream - LED Linear Lamp (TLED)<br>with Controls | CI_EQUIP | All | -0.000162 |
| Lighting Upstream - LED Exterior with Controls              | CI_EQUIP | All | n/a       |

Heating penalties for downstream, interior lighting systems (non-turnkey) are from the 12-month data logging study.<sup>3</sup> Penalties for interior, turnkey are from the 2018 small business lighting impact evaluation<sup>4</sup>. Penalties for upstream lighting products are from the 2017 upstream lighting impact evaluation<sup>5</sup>.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name                                  | Core Initiative                   | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------------|-----------------------------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Lighting Systems - Interior                   | CI_NB&MR<br>CI_EQUIP,<br>CI_RETRO | All | 1.00 | 1.12            | 1.12             | 1.00             | 1.00             | 0.80             | 0.61             |
| Lighting Systems - Exterior                   | CI_NB&MR<br>CI_EQUIP,<br>CI_RETRO | All | 1.00 | 1.12            | 1.12             | 1.00             | 1.00             | 0.00             | 1.00             |
| Lighting Systems – Interior (Turnkey)         | CI_RETRO                          | All | 1.00 | 0.93            | 0.93             | 0.91             | 1.03             | 0.57             | 0.58             |
| Lighting Systems – Exterior (Turnkey)         | CI_RETRO                          | All | 1.00 | 0.93            | 0.93             | 0.91             | 1.03             | 0.00             | 1.00             |
| Lighting Upstream – LED Linear                | CI_EQUIP                          | All | 1.00 | 0.88            | 0.88             | 0.99             | 0.99             | 0.72             | 0.66             |
| Lighting Upstream – LED Screw In              | CI_EQUIP                          | All | 1.00 | 0.61            | 0.61             | 0.70             | 0.55             | 0.59             | 0.52             |
| Lighting Upstream – LED Stairwell             | CI_EQUIP                          | All | 1.00 | 0.86            | 0.86             | 0.86             | 0.86             | 0.81             | 0.82             |
| Lighting Upstream – LED Linear w/<br>Controls | CI_EQUIP                          | All | 1.00 | 0.94            | 0.94             | 1.06             | 0.91             | 0.72             | 0.66             |
| Lighting Upstream – High/Low Bay              | CI_EQUIP                          | All | 1.00 | 0.91            | 0.91             | 1.02             | 0.88             | 0.72             | 0.66             |
| Lighting Upstream – LED Exterior              | CI_EQUIP                          | All | 1.00 | 0.92            | 0.92             | 0.92             | 0.92             | 0.00             | 1.00             |

|                                                          |          |     |      |      |      |      |      |      |      |
|----------------------------------------------------------|----------|-----|------|------|------|------|------|------|------|
| Lighting Upstream – High/Low Bay w/ Controls             | CI_EQUIP | All | 1.00 | 0.91 | 0.91 | 1.02 | 0.88 | 0.72 | 0.66 |
| Lighting Upstream - LED Linear Lamp (TLED) with Controls | CI_EQUIP | All | 1.00 | 0.88 | 0.88 | 0.99 | 0.85 | 0.72 | 0.66 |
| Lighting Upstream - LED Exterior with Controls           | CI_EQUIP | All | 1.00 | 0.92 | 0.92 | 0.92 | 0.92 | 0.00 | 1.00 |

### **In-Service Rates:**

All downstream installations have 100% in service rate since programs include verification of equipment installations. All upstream in-service rates are incorporated into the realization rates, so the ISR is set to 1.00 to avoid double counting.

### **Realization Rates:**

- C&I New Construction: For all measures except Upstream Lighting, all PAs Energy and Demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.<sup>6</sup>
- C&I Upstream: Upstream Lighting Energy RR includes connected kW RR, Hours of Use RR, In service rate, and HVAC Interactive adjustment. All Upstream Lighting Demand RR includes the connected kW RR and demand interactive adjustment.<sup>7</sup>
- C&I Existing Building Retrofit: All PAs energy and demand RRs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs. Demand RR is the connected demand RR; energy RR includes connected kWh RR, hours of use RR and HVAC Interactive adjustment.<sup>8</sup>
- C&I Small Business: Energy and demand RRs are the statewide results from the 2018 Small Business Impact Evaluation - Phase I and subsequent correction memo to adjust interactive effects.<sup>9</sup>

### **Coincidence Factors:**

- C&I New Construction: For all measures except Upstream Lighting, all CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.<sup>10</sup>
- C&I Upstream: All PAs CFs are from the 2017 Upstream Lighting Impact evaluation.<sup>11</sup>
- C&I Existing Building Retrofit: All CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.<sup>12</sup>
- C&I Small Business: All PAs use CF values from the 2018 Small Business Impact Evaluation - Phase I and subsequent correction memo to adjust interactive effects.<sup>13</sup>

### **Impact Factors for Calculating Net Savings:**

2022 Net-to-gross values are based on study results.<sup>14 15</sup>

| Measure Name                         | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|--------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Lighting System – Interior           | CI_NB&MR        | All | 0.583 | 0.227           | n/a              | 0.644 |
| Lighting System – Exterior           | CI_NB&MR        | All | 0.583 | 0.227           | n/a              | 0.644 |
| Lighting System – Interior (Turnkey) | CI_RETRO        | All | 0.151 | 0.013           | 0.004            | 0.866 |



|                                      |          |     |       |       |       |       |
|--------------------------------------|----------|-----|-------|-------|-------|-------|
| Lighting System – Exterior (Turnkey) | CI_RETRO | All | 0.151 | 0.013 | 0.004 | 0.866 |
| Lighting System – Interior           | CI_RETRO | All | 0.232 | 0.01  | 0.016 | 0.785 |
| Lighting System – Exterior           | CI_RETRO | All | 0.232 | 0.01  | 0.016 | 0.785 |
| Lighting System – Interior           | CI_EQUIP | All | 0.25  | 0.002 | 0.085 | 0.837 |
| Lighting System – Exterior           | CI_EQUIP | All | 0.25  | 0.002 | 0.085 | 0.837 |

### Upstream Net-to-Gross for 2022

Upstream lighting NTG are per the 2021 upstream lighting NTG study.<sup>16</sup>

| Measure Name                                                | Core Initiative | PA  | 2022 | 2022 | 2023 | 2023 | 2024 | 2024 |
|-------------------------------------------------------------|-----------------|-----|------|------|------|------|------|------|
|                                                             |                 |     | FR   | NTG  | FR   | NTG  | FR   | NTG  |
| Lighting Upstream – LED Linear                              | CI_EQUIP        | All | 0.74 | 0.26 | 0.80 | 0.20 | 0.86 | 0.14 |
| Lighting Upstream – LED Screw In                            | CI_EQUIP        | All | 0.55 | 0.45 | 0.60 | 0.40 | 0.65 | 0.35 |
| Lighting Upstream – LED Stairwell                           | CI_EQUIP        | All | 0.74 | 0.26 | 0.80 | 0.20 | 0.86 | 0.14 |
| Lighting Upstream - LED Linear Fixtures                     | CI_EQUIP        | All | 0.73 | 0.27 | 0.78 | 0.22 | 0.83 | 0.17 |
| Lighting Upstream – LED Linear Fixtures w/<br>Controls      | CI_EQUIP        | All | 0.42 | 0.58 | 0.44 | 0.56 | 0.47 | 0.53 |
| Lighting Upstream – High/Low Bay                            | CI_EQUIP        | All | 0.51 | 0.49 | 0.56 | 0.44 | 0.62 | 0.38 |
| Lighting Upstream – LED Exterior                            | CI_EQUIP        | All | 0.83 | 0.17 | 0.88 | 0.12 | 0.93 | 0.07 |
| Lighting Upstream - High/Low Bay w/Controls                 | CI_EQUIP        | All | 0.51 | 0.49 | 0.56 | 0.44 | 0.62 | 0.38 |
| Lighting Upstream - LED Linear Lamp (TLED)<br>with Controls | CI_EQUIP        | All | 0.74 | 0.26 | 0.80 | 0.20 | 0.86 | 0.14 |
| Lighting Upstream - LED Exterior with<br>Controls           | CI_EQUIP        | All | 0.83 | 0.17 | 0.88 | 0.12 | 0.93 | 0.07 |

### Non-Energy Impacts:

Non-energy benefits come from the 2021 NEI study.<sup>17</sup>

| Measure Name                | Core Initiative    | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------|--------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Lighting Systems - Interior | CI_NB&MR, CI_EQUIP | All |                    |                      | \$0.048           |                     |                     |                       |

|                                                          |                    |     |  |  |         |  |  |  |
|----------------------------------------------------------|--------------------|-----|--|--|---------|--|--|--|
| Lighting Systems - Exterior                              | CI_NB&MR, CI_EQUIP | All |  |  | \$0.048 |  |  |  |
| Lighting Systems - Interior                              | CI_RETRO           | All |  |  | \$0.048 |  |  |  |
| Lighting Systems - Exterior                              | CI_RETRO           | All |  |  | \$0.048 |  |  |  |
| Lighting Systems – Interior (Turnkey)                    | CI_RETRO           | All |  |  | \$0.048 |  |  |  |
| Lighting Systems – Exterior (Turnkey)                    | CI_RETRO           | All |  |  | \$0.048 |  |  |  |
| Lighting Upstream – LED Linear                           | CI_EQUIP           | All |  |  | \$0.048 |  |  |  |
| Lighting Upstream – LED Screw In                         | CI_EQUIP           | All |  |  | \$0.048 |  |  |  |
| Lighting Upstream – LED Stairwell                        | CI_EQUIP           | All |  |  | \$0.048 |  |  |  |
| Lighting Upstream – LED Linear w/ Controls               | CI_EQUIP           | All |  |  | \$0.106 |  |  |  |
| Lighting Upstream – High/Low Bay                         | CI_EQUIP           | All |  |  | \$0.048 |  |  |  |
| Lighting Upstream – LED Exterior                         | CI_EQUIP           | All |  |  | \$0.048 |  |  |  |
| Lighting Upstream - High/Low Bay w/Controls              | CI_EQUIP           | All |  |  | \$0.106 |  |  |  |
| Lighting Upstream - LED Linear Lamp (TLED) with Controls | CI_EQUIP           | All |  |  | \$0.106 |  |  |  |
| Lighting Upstream - LED Exterior with Controls           | CI_EQUIP           | All |  |  | \$0.106 |  |  |  |

**Endnotes:**

**1** : DNV (2021). Impact Evaluation of PY2019 Massachusetts C&I Upstream Lighting Initiative. [2021 DNV Upstream Lighting Impact Report](#)

**2** : Downstream hours of use leverage the upstream evaluation HOU study previously referenced where applicable, and include additional layers of granularity for those building types not covered by the evaluation and in accordance with NY TRM guidance and/or engineering judgement. Parking garage

HOU are lower than upstream assumption as there isn't an explicit requirement for 24/7 usage per code.

**2** : [2021 DNV CI Lighting Adjusted Measure Life 2021-2022 Memo](#)

**3** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.  
[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**4** : DNV GL, ERS (2018). Impact Evaluation of PY2016 Small Business Initiative: Phase I  
[2018 DNVGL ERS SBS Impact](#)

**5** : DNV GL (2017). Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative. [DNVGL 2017 Upstream Lighting Impact Evaluation](#)

**6** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.  
[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**7** : [2021 DNV Upstream Lighting Impact Report](#)

**8** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.  
[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**9** : DNV GL (2018). Impact Evaluation of PY2016 Massachusetts Commercial & Industrial Small Business Initiative: Phase I (Lighting). [2018 DNVGL ERS SBS Impact](#)

**10** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.  
[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**11** : DNV GL (2017). Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative. [DNVGL 2017 Upstream Lighting Impact Evaluation](#)

**12** : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations.  
[DNV KEMA 2013 Prescriptive Ltg Impact Eval PY2010](#)

**13** : DNV GL (2018). Impact Evaluation of PY2016 Massachusetts Commercial & Industrial Small Business Initiative: Phase I (Lighting). [2018 DNVGL ERS SBS Impact](#)

**14** : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)

**15** : [2021 DNV CI Lighting Upstream NTG 2022-2024](#)

**16** : [2021 DNV CI Lighting Upstream NTG 2022-2024](#)

**17** : C&I O&M and Non-O&M NEI Study with Deemed H&S component

### 3.84. Motor - Variable Frequency Drive

|                        |                    |
|------------------------|--------------------|
| <b>Measure Code</b>    | COM-MAD-VFD        |
| <b>Market</b>          | Commercial         |
| <b>Program Type</b>    | Retrofit           |
| <b>Category</b>        | Motors and Drives  |
| <b>Sub Category</b>    | Motors and Drives  |
| <b>TRM Version</b>     | 2022-2024 Plan TRM |
| <b>Measure Version</b> | 5                  |

#### Measure Description:

This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.

#### BCR Measure IDs:

| Measure Name                          | Core Initiative                           | BCR Measure ID |
|---------------------------------------|-------------------------------------------|----------------|
| Prescriptive - Motors & VFD (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a054        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (HP)(kWh/HP)$$

$$\Delta kW = (HP)(kW/HP_{SP})$$

Where:

**HP** = Rated horsepower for the impacted motor.

**kWh / HP** = Annual electric energy reduction based on building and equipment type. See table below.

**kW / HP<sub>SP</sub>** = Summer demand reduction based on building and equipment type. See table below.

**kW / HP<sub>WP</sub>** = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

#### Savings Factors for C&I VFDs (kWh/HP<sup>1</sup> and kW/HP<sup>2</sup>)

| Building Type | Building Exhaust Fan | Cooling Tower Fan | Chilled Water Pump | Boiler Feed Water Pump | Hot Water Circulating Pump | MAF - Make-up Air Fan | Return Fan | Supply Fan | WS Heat Pump Circula |
|---------------|----------------------|-------------------|--------------------|------------------------|----------------------------|-----------------------|------------|------------|----------------------|
|---------------|----------------------|-------------------|--------------------|------------------------|----------------------------|-----------------------|------------|------------|----------------------|

|                                                      |       |        |       |       |       |       |       |       | ting Loop |
|------------------------------------------------------|-------|--------|-------|-------|-------|-------|-------|-------|-----------|
| Annual Energy Savings Factors (kWh/HP)               |       |        |       |       |       |       |       |       |           |
| University/ College                                  | 3641  | 449    | 745   | 2316  | 2344  | 3220  | 1067  | 1023  | 3061      |
| Elm/H School                                         | 3563  | 365    | 628   | 1933  | 1957  | 3402  | 879   | 840   | 2561      |
| Multi-Family                                         | 3202  | 889    | 1374  | 2340  | 2400  | 3082  | 1374  | 1319  | 3713      |
| Hotel/Motel                                          | 3151  | 809    | 1239  | 2195  | 2239  | 3368  | 1334  | 1290  | 3433      |
| Health                                               | 3375  | 1705   | 2427  | 2349  | 2406  | 3002  | 1577  | 1487  | 3670      |
| Warehouse                                            | 3310  | 455    | 816   | 2002  | 2087  | 3229  | 1253  | 1205  | 2818      |
| Restaurant                                           | 3440  | 993    | 1566  | 1977  | 2047  | 2628  | 1425  | 1363  | 3542      |
| Retail                                               | 3092  | 633    | 1049  | 1949  | 2000  | 2392  | 1206  | 1146  | 2998      |
| Grocery                                              | 3126  | 918    | 1632  | 1653  | 1681  | 2230  | 1408  | 1297  | 3285      |
| Offices                                              | 3332  | 950    | 1370  | 1866  | 1896  | 3346  | 1135  | 1076  | 3235      |
| Summer Demand Savings Factors (kW/HP <sub>SP</sub> ) |       |        |       |       |       |       |       |       |           |
| University/ College                                  | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Elm/H School                                         | 0.377 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Multi-Family                                         | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Hotel/Motel                                          | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Health                                               | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Warehouse                                            | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.261 | 0.287 | 0.274 | 0.218     |
| Restaurant                                           | 0.261 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Retail                                               | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Grocery                                              | 0.261 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Offices                                              | 0.109 | -0.023 | 0.174 | 0.457 | 0.091 | 0.109 | 0.287 | 0.274 | 0.218     |
| Winter Demand Savings Factors (kW/HP <sub>WP</sub> ) |       |        |       |       |       |       |       |       |           |
| University/ College                                  | 0.377 | -0.006 | 0.184 | 0.457 | 0.21  | 0.109 | 0.26  | 0.252 | 0.282     |

|                            |       |        |       |       |      |       |      |       |       |
|----------------------------|-------|--------|-------|-------|------|-------|------|-------|-------|
| Elementary/<br>High School | 0.457 | -0.006 | 0.184 | 0.457 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Multi-<br>Family           | 0.109 | -0.006 | 0.184 | 0.355 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Hotel/Motel                | 0.109 | -0.006 | 0.184 | 0.418 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Health                     | 0.377 | -0.006 | 0.184 | 0.275 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Warehouse                  | 0.377 | -0.006 | 0.184 | 0.178 | 0.21 | 0.261 | 0.26 | 0.252 | 0.282 |
| Restaurant                 | 0.109 | -0.006 | 0.184 | 0.355 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Retail                     | 0.109 | -0.006 | 0.184 | 0.275 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Grocery                    | 0.457 | -0.006 | 0.184 | 0.418 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |
| Offices                    | 0.457 | -0.006 | 0.184 | 0.418 | 0.21 | 0.109 | 0.26 | 0.252 | 0.282 |

### Baseline Efficiency:

The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheats.

### High Efficiency:

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

### Measure Life:

This measure has been determined to be an add on single baseline measure for retrofit scenarios.<sup>4</sup>

| Measure Name                          | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Prescriptive - Motors & VFD (Turnkey) | CI_RETRO        | All | 10  | n/a | n/a | 10  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name  | Core Initiative | PA                  | ISR  | RR <sub>E</sub> <sup>5</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------|-----------------|---------------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| VFD (turnkey) | CI_RETRO        | Eversource / Unitil | 1.00 | 0.946                        | n/a              | 1.265            | 1.415            | 1.00             | 1.00             |
| VFD (turnkey) | CI_RETRO        | National Grid / CLC | 1.00 | 1.049                        | n/a              | 0.941            | 1.174            | 1.00             | 1.00             |

### In-Service Rates:

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

- Energy and Demand RRs for Turnkey installations are based on the Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures study <sup>8</sup>.

**Coincidence Factors:**

CFs for all PAs set to 1.0 since summer and winter demand savings are based on evaluation results.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results for non-residential end use measures.<sup>10</sup>

| Measure Name                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|------------------------------|-----------------|-----|------|-----------------|------------------|------|
| VFD - Prescriptive (Turnkey) | CI_RETRO        | All | 0.13 | 0.05            | 0.02             | 0.94 |

**Non-Energy Impacts:**

| Measure Name                 | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh <sup>11</sup> | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------------|-----------------|-----|--------------------|----------------------|---------------------------------|---------------------|---------------------|-----------------------|
| VFD - Prescriptive (Turnkey) | CI_RETRO        | All |                    |                      | \$0.002                         |                     |                     |                       |

**Endnotes:**

**1** : Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.

[Chan 2010 Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR](#)

**2** : Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.

[Chan 2010 Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR](#)

**4** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.

[2018 DNVGL ERS Portfolio Model Companion Sheet](#)

**8** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures.

[Final Report MA19C03-E-SBIMPCT 03202020](#)

**7** : DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.

**11** : MA20X10-B-CIOMNEI

### 3.85. Motor - Variable Frequency Drive - C&I Multi-Family

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | COM-MAD-VFDREU    |
| <b>Market</b>       | Commercial        |
| <b>Program Type</b> | Retrofit          |
| <b>Category</b>     | Motors and Drives |

#### Measure Description:

This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.

#### BCR Measure IDs:

| Measure Name                                | Core Initiative                           | BCR Measure ID |
|---------------------------------------------|-------------------------------------------|----------------|
| Custom - Motors & VFD (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a109        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (HP)(kWh/HP)$$

$$\Delta kW = (HP)(kW/HP_{SP})$$

Where:

**HP** = Rated horsepower for the impacted motor.

**kWh / HP** = Annual electric energy reduction based on building and equipment type. See table below.

**kW / HP<sub>SP</sub>** = Summer demand reduction based on building and equipment type. See table below.

**kW / HP<sub>WP</sub>** = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.



**Savings Factors for VFDs<sup>1 2</sup> (kWh/HP and kW/HP)**

| Building Type                                        | Building Exhaust Fan | Cooling Tower Fan | Chilled Water Pump | Boiler Feed Water Pump | Hot Water Circulating Pump | MAF - Make-up Air Fan | Return Fan | Supply Fan | WS Heat Pump Circulating Loop |
|------------------------------------------------------|----------------------|-------------------|--------------------|------------------------|----------------------------|-----------------------|------------|------------|-------------------------------|
| Annual Energy Savings Factors (kWh/HP)               |                      |                   |                    |                        |                            |                       |            |            |                               |
| Multi-Family                                         | 3202                 | 889               | 1633               | 2340                   | 1548                       | 3082                  | 1788       | 2033       | 2562                          |
| Summer Demand Savings Factors (kW/HP <sub>SP</sub> ) |                      |                   |                    |                        |                            |                       |            |            |                               |
| Multi-Family                                         | 0.109                | -0.023            | 0.183              | 0.457                  | 0.096                      | 0.109                 | 0.302      | 0.288      | 0.229                         |
| Winter Demand Savings Factors (kW/HP <sub>WP</sub> ) |                      |                   |                    |                        |                            |                       |            |            |                               |
| Multi-Family                                         | 0.109                | -0.006            | 0.194              | 0.355                  | 0.221                      | 0.109                 | 0.274      | 0.265      | 0.297                         |

**Baseline Efficiency:**

The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheats.

**High Efficiency:**

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

**Measure Life:**

The measure life is 13 years.<sup>3</sup>

| Measure Name               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------|-----------------|-----|-----|-----|-----|-----|
| VFDs (Residential End Use) | CI_RETRO        | All | 13  | n/a | n/a | 13  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name               | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| VFDs (Residential End Use) | CI_RETRO        | All | 1.00 | 0.86            | 1.00             | 0.86             | 0.86             | 1.00             | 1.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Realization rate is based on evaluation results.<sup>4</sup>

**Coincidence Factors:**

CFs for all PAs set to 1.0 since summer and winter demand savings are based on evaluation results.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>5</sup>

| Measure Name               | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------|-----------------|-----|------|-----------------|------------------|------|
| VFDs (Residential End Use) | CI_RETRO        | All | 0.05 | 0.01            | 0.05             | 1.02 |

**Non-Energy Impacts:**

NEI values are rolled up, component values can be found in Appendix B.

| Measure Name              | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|---------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| VFD (Residential End Use) | CI_RETRO        | All | \$0.00             | \$0.00               | \$0.20            | \$0.00              | \$0.00              | \$0.00                |

**Endnotes:**

**1 :** For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW and kWh /HP estimates derived from Cadmus (2012). Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR. [Cadmus 2014 VSD Loadshape Project](#)

**2 :** For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW and kWh /HP estimates derived from Cadmus (2012). Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.

[Chan 2010 Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Ta](#)

[bles at NSTAR](#)

**3** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

**4** : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)

**5** : NMR Group, Inc. (2021). C&I Prescriptive and Custom NTG Omnibus Study [2021 NMR Prescriptive and Custom Net-to-Gross Omnibus Study](#)

### 3.86. Motor - Variable Frequency Drive with Motor

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | COM-MD-MVFD       |
| <b>Market</b>       | Commercial        |
| <b>Program Type</b> | Retrofit          |
| <b>Category</b>     | Motors and Drives |

#### Measure Description:

This measure covers the installation of a high efficiency motor with a variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.

#### BCR Measure IDs:

| Measure Name                | Core Initiative                                  | BCR Measure ID |
|-----------------------------|--------------------------------------------------|----------------|
| Prescriptive - Motors & VFD | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a025        |
| Prescriptive - Motors & VFD | C&I Existing Building Retrofit (CI_RETRO)        | EC2a020        |
| Prescriptive - Motors & VFD | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b024        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (HP)(kWh/HP)$$

$$\Delta kW = (HP)(kW/HP_{SP})$$

Where:

HP = Rated horsepower for the impacted motor.

kWh / HP = Annual electric energy reduction based on building and equipment type. See table below.

kW / HP<sub>SP</sub> = Summer demand reduction based on building and equipment type. See table below.

kW / HP<sub>WP</sub> = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

**Savings Factors for C&I VFDs with Motor Replacement (kWh/HP<sup>1</sup> and kW/HP<sup>2</sup>) :**

| <b>Building Type</b>                                 | <b>Building Exhaust Fan</b> | <b>Cooling Tower</b> | <b>Chilled Water Pump</b> | <b>Boiler Feed Water Pump</b> | <b>Hot Water Circulating Pump</b> | <b>MAF Make-up Air Fan</b> | <b>Return Fan</b> | <b>Supply Fan</b> |
|------------------------------------------------------|-----------------------------|----------------------|---------------------------|-------------------------------|-----------------------------------|----------------------------|-------------------|-------------------|
| Annual Energy Savings Factors (kWh/HP)               |                             |                      |                           |                               |                                   |                            |                   |                   |
| University/College                                   | 3,802                       | 486                  | 780                       | 2,415                         | 2,442                             | 3,381                      | 1,143             | 1,100             |
| Elm/H School                                         | 3,721                       | 396                  | 657                       | 2,015                         | 2,040                             | 3,561                      | 941               | 903               |
| Multi-Family                                         | 3,368                       | 954                  | 1,435                     | 2,443                         | 2,504                             | 3,248                      | 1,466             | 1,412             |
| Hotel/Motel                                          | 3,317                       | 866                  | 1,294                     | 2,291                         | 2,335                             | 3,534                      | 1,425             | 1,381             |
| Health                                               | 3,541                       | 1,815                | 2,535                     | 2,453                         | 2,510                             | 3,168                      | 1,676             | 1,586             |
| Warehouse                                            | 3,476                       | 496                  | 853                       | 2,098                         | 2,183                             | 3,396                      | 1,342             | 1,294             |
| Restaurant                                           | 3,606                       | 1,066                | 1,636                     | 2,067                         | 2,138                             | 2,794                      | 1,519             | 1,457             |
| Retail                                               | 3,258                       | 685                  | 1,097                     | 2,036                         | 2,087                             | 2,558                      | 1,288             | 1,229             |
| Grocery                                              | 3,292                       | 1,001                | 1,710                     | 1,724                         | 1,753                             | 2,396                      | 1,498             | 1,386             |
| Offices                                              | 3,498                       | 1,014                | 1,432                     | 1,947                         | 1,977                             | 3,512                      | 1,210             | 1,151             |
| Summer Demand Savings Factors (kW/HP <sub>SP</sub> ) |                             |                      |                           |                               |                                   |                            |                   |                   |
| University/College                                   | 0.257                       | (0.004)              | 0.465                     | 0.952                         | 0.190                             | 0.257                      | 0.679             | 0.706             |
| Elm/H School                                         | 1.187                       | (0.006)              | 0.697                     | 1.428                         | 0.286                             | 0.385                      | 1.019             | 1.058             |
| Multi-Family                                         | 0.385                       | (0.006)              | 0.697                     | 1.428                         | 0.286                             | 0.385                      | 1.019             | 1.058             |
| Hotel/Motel                                          | 0.257                       | (0.004)              | 0.465                     | 0.952                         | 0.190                             | 0.257                      | 0.679             | 0.706             |
| Health                                               | 0.128                       | (0.002)              | 0.232                     | 0.476                         | 0.095                             | 0.128                      | 0.340             | 0.353             |
| Warehouse                                            | 0.770                       | (0.012)              | 1.394                     | 2.855                         | 0.571                             | 1.677                      | 2.038             | 2.117             |
| Restaurant                                           | 0.839                       | (0.006)              | 0.697                     | 1.428                         | 0.286                             | 0.385                      | 1.019             | 1.058             |
| Retail                                               | 0.514                       | (0.008)              | 0.930                     | 1.904                         | 0.381                             | 0.514                      | 1.358             | 1.411             |
| Grocery                                              | 0.280                       | (0.002)              | 0.232                     | 0.476                         | 0.095                             | 0.128                      | 0.340             | 0.353             |

|                                                      |       |         |       |       |       |       |       |       |
|------------------------------------------------------|-------|---------|-------|-------|-------|-------|-------|-------|
| Offices                                              | 0.257 | (0.004) | 0.465 | 0.952 | 0.190 | 0.257 | 0.679 | 0.706 |
| Winter Demand Savings Factors (kW/HP <sub>WP</sub> ) |       |         |       |       |       |       |       |       |
| University/<br>College                               | 0.791 | (0.001) | 0.384 | 0.952 | 0.437 | 0.257 | 0.563 | 0.544 |
| Elementary/<br>High School                           | 1.428 | (0.002) | 0.575 | 1.428 | 0.655 | 0.385 | 0.844 | 0.816 |
| Multi-<br>Family                                     | 0.385 | (0.002) | 0.575 | 1.123 | 0.661 | 0.385 | 0.844 | 0.816 |
| Hotel/Motel                                          | 0.257 | (0.001) | 0.384 | 0.874 | 0.438 | 0.257 | 0.563 | 0.544 |
| Health                                               | 0.396 | (0.001) | 0.192 | 0.294 | 0.223 | 0.128 | 0.281 | 0.272 |
| Warehouse                                            | 2.374 | (0.003) | 1.151 | 1.181 | 1.384 | 1.677 | 1.688 | 1.632 |
| Restaurant                                           | 0.385 | (0.002) | 0.575 | 1.123 | 0.661 | 0.385 | 0.844 | 0.816 |
| Retail                                               | 0.514 | (0.002) | 0.767 | 1.178 | 0.893 | 0.514 | 1.125 | 1.088 |
| Grocery                                              | 0.476 | (0.001) | 0.192 | 0.437 | 0.219 | 0.128 | 0.281 | 0.272 |
| Offices                                              | 0.952 | (0.001) | 0.384 | 0.874 | 0.438 | 0.257 | 0.563 | 0.544 |

### Baseline Efficiency:

In the baselines, air or water volume/temperature is controlled using valves, dampers, and/or reheats.

### High Efficiency:

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

### Measure Life:

This measure was determined to have an add on single baseline for retrofit applications.<sup>3 4</sup>

| Measure Name   | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------|-----------------|-----|-----|-----|-----|-----|
| VFD with Motor | CI_RETRO        | All | 15  | n/a | n/a | 15  |

### Other Resource Impacts:

There are no other resource impacts identified for this measure.

### Impact Factors for Calculating Adjusted Gross Savings:

| Measure Name | Core Initiative | PA | ISR | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|----|-----|-----------------|------------------|------------------|------------------|------------------|------------------|
|--------------|-----------------|----|-----|-----------------|------------------|------------------|------------------|------------------|------------------|

|                          |          |                     |      |       |     |       |       |      |      |
|--------------------------|----------|---------------------|------|-------|-----|-------|-------|------|------|
| VFD with Motor           | CI_RETRO | All                 | 1.00 | 0.94  | n/a | 1.00  | 1.00  | 1.00 | 1.00 |
| VFD with Motor (Turnkey) | CI_RETRO | Eversource / Unitil | 1.00 | 0.946 | n/a | 1.265 | 1.415 | 1.00 | 1.00 |
| VFD with Motor (Turnkey) | CI_RETRO | National Grid / CLC | 1.00 | 1.049 | n/a | 0.941 | 1.174 | 1.00 | 1.00 |

**In-Service Rates:**

All installations have 100% in service rate since all PAs programs include verification of equipment installations.

**Realization Rates:**

Energy RRs for all PAs based on impact evaluation of 2011-2012 prescriptive VSD projects<sup>5</sup> Demand RRs from study not used due to low precision of demand results. Demand RRs for Chilled Water Pump, Hot Water Circ.

Pump, Return Fan, Supply Fan, and WSHP Circ. Loop set to 1 since savings based on NEEP VSD Loadshape study.

Energy and Demand RRs for Turnkey installations are based on the Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures study.<sup>6</sup>

**Coincidence Factors:**

CFs for all PAs set to 1.0 since summer and winter demand savings are based on evaluation results.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>8</sup>

Net-to-gross values for the New Buildings and Major Renovations Core Initiative are based on study results.<sup>9</sup>

| Measure Name   | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------|-----------------|-----|------|-----------------|------------------|------|
| VFD with Motor | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |
| VFD with Motor | CI_NB&MR        | All | 0.58 | 0.22            | 0.00             | 0.64 |

**Non-Energy Impacts:**

| Measure Name   | Core Initiative      | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh <sup>13</sup> | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------|----------------------|-----|--------------------|----------------------|---------------------------------|---------------------|---------------------|-----------------------|
| VFD with motor | CI_RETRO<br>CI_NB&MR | All |                    |                      | \$0.002                         |                     |                     |                       |

**Endnotes:**

**1** : Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at Eversource (NSTAR). Prepared for NSTAR.

[Chan 2010 Formulation of a Prescriptive Incentive for the VFD and Motors and VFD Impact Tables at NSTAR](#)

**2** : For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW/HP estimates derived from Cadmus (2012). Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type kW/HP savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR. Prepared for NSTAR.

**3** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.

[2018 DNVGL ERS Portfolio Model Companion Sheet](#)

**4** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)

**5** : KEMA, Inc. and DMI, Inc. (2013). 2011-2012 Massachusetts Prescriptive VSD Impact Evaluation. [KEMA 2013 Prescriptive VSD Report](#)

**6** : DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.

**9** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.

[2021 NMR C&I Omnibus NTG](#)

**8** : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)

**13** : MA20X10-B-CIOMNEI



### 3.87. Other - Codes and Standards Advocacy

|                     |                                    |
|---------------------|------------------------------------|
| <b>Measure Code</b> | COM-CM-CSA                         |
| <b>Market</b>       | Commercial                         |
| <b>Program Type</b> | Lost Opportunity, New Construction |
| <b>Category</b>     | Custom, Other                      |

#### Measure Description:

The Mass Save Codes and Standards Advocacy program works with stakeholders to advocate for higher energy code and appliance standards. This Advocacy is on both the state and federal level.

#### BCR Measure IDs:

| Measure Name                  | Core Initiative                                  | BCR Measure ID |
|-------------------------------|--------------------------------------------------|----------------|
| Codes Development and Support | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a053        |
| Standards Adoption            | C&I New & Replacement Equipment (CI_EQUIP)       | EC2b121        |
| Codes Development and Support | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a034        |
| Standards Adoption            | C&I New & Replacement Equipment (CI_EQUIP)       | GC2b058        |

#### Algorithms for Calculating Primary Energy Impact:

Savings for Program Administrator activity in the Codes and Standards Advocacy initiative will be reviewed on a case by case basis. Each activity will have its own unique level of effort and its own corresponding level of savings.

Savings for the Codes Development and Support measure are outlined in the table below. There are no Gas PA C&I savings for this measure. Savings are based on an evaluation study.<sup>1</sup> Savings were distributed among electric PAs based on C&I customer counts.

| Savings (MWh) |       |       |       |
|---------------|-------|-------|-------|
| PA            | 2022  | 2023  | 2024  |
| CLC           | 241   | 492   | 642   |
| Eversource    | 1,519 | 3,095 | 4,044 |
| National Grid | 1,480 | 3,016 | 3,941 |
| Unitil        | 39    | 80    | 104   |

| <b>Savings (Therms) - Electric Interactive Effects</b> |         |          |          |
|--------------------------------------------------------|---------|----------|----------|
| PA                                                     | 2022    | 2023     | 2024     |
| CLC                                                    | (833)   | (1,698)  | (2,219)  |
| Eversource                                             | (5,247) | (10,689) | (13,971) |
| National Grid                                          | (5,113) | (10,417) | (13,615) |
| Unitil                                                 | (135)   | (276)    | (361)    |

**Baseline Efficiency:**

The baseline level of efficiency will also be determined on a case by case basis. The baseline level of efficiency for each avenue of advocacy would correspond to the energy code or appliance standard that would have been in place without the intervention of the Program Administrators.

**High Efficiency:**

The high efficiency case would be the energy code or appliance standard that was advocated for by the Program Administrators.

**Measure Life:**

The measure life is assumed to be 20 years but could be adjusted on a case by case basis.

| Measure Name                  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-------------------------------|-----------------|-----|-----|-----|-----|-----|
| Codes Development and Support | CI_NB&MR        | All | 20  | n/a | n/a | 20  |
| Standards Adoption, Electric  | CI_EQUIP        | All | 11  | n/a | n/a | 11  |
| Standards Adoption, Gas       | CI_EQUIP        | All | 10  | n/a | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                  | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Codes Development and Support | CI_NB&MR        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | n/a              | n/a              |
| Standards Adoption            | CI_EQUIP        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | n/a              | n/a              |

**In-Service Rates:**

All PAs use 100% in service rate.

**Realization Rates:**

All PAs use 100% realization rates.

**Coincidence Factors:**

Per Statewide agreement, kW will not be claimed for this measure.

**Impact Factors for Calculating Net Savings:**

The net-to-gross value is assumed to be 100% but will be adjusted on a case by case basis. Each activity will have its own unique level of effort and its own corresponding net-to-gross value.

| Measure Name                  | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Codes Development and Support | CI_NB&MR        | All | 0.00 | 0.00            | 0.00             | 1.00 |
| Standards Adoption            | CI_EQUIP        | All | 0.00 | 0.00            | 0.00             | 1.00 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

1 : NMR Group, Inc. (2020) Code Promulgation Attribution Study  
[2020 NMR Code Promulgation Attribution Study](#)

### 3.88. Plug Load - Advanced Power Strip

|                     |            |
|---------------------|------------|
| <b>Measure Code</b> | COM-PL-APS |
| <b>Market</b>       | Commercial |
| <b>Program Type</b> | Retrofit   |
| <b>Category</b>     | Plug Load  |

#### Measure Description:

Advanced power strips can automatically eliminate standby power loads of electronic peripheral devices that are not needed (DVD player, computer printer, scanner, etc.) either automatically or when an electronic control device (typically a television or personal computer) is in standby or off mode.

#### BCR Measure IDs:

| Measure Name                      | Core Initiative                           | BCR Measure ID |
|-----------------------------------|-------------------------------------------|----------------|
| Smart Strip (Residential End Use) | C&I Existing Building Retrofit (CI_RETRO) | EC2a099        |

#### Algorithms for Calculating Primary Energy Impact:

Unit kWh savings are deemed based on study results.<sup>1</sup> Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.<sup>2</sup>

#### Savings for Smart Strips

| Measure Name | Core Initiative | kWh | kW    |
|--------------|-----------------|-----|-------|
| Smart Strip  | CI_RETRO        | 105 | 0.010 |

#### Baseline Efficiency:

The baseline efficiency case is the customers' devices as they are currently operating.

#### High Efficiency:

The high efficiency case is the installation of an Advanced Power Strip.

#### Measure Life:

The measure life is 5 years.

#### Other Resource Impacts:

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|
| Smart Strip  | CI_RETRO        | All | 0.73 | 0.92            | 0.92             | 0.92             | 1.00             | 1.00             |

**In-Service Rates**

In-Service Rates are blended and based on evaluation results.<sup>3 4</sup>

**Realization Rates**

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.<sup>5</sup>

**Coincidence Factors**

From evaluation study.<sup>6</sup>

**Impact Factors for Calculating Net Savings:**

PAs use state-wide prescriptive net-to-gross values based on the 2021 C&I Omnibus NTG Study.<sup>7</sup>

| Measure Name      | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------|-----------------|-----|------|-----------------|------------------|------|
| Room Air Purifier | CI_EQUIP        | All | 0.25 | 0.00            | 0.09             | 0.84 |

**Non-Energy Impacts:**

There are no non-energy impacts identified for this measure.

**Endnotes:**

- 
- 1 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study.  
[2019 NMR APSMeteringReport Revised](#)
  - 2 : Guidehouse (2020). Residential Baseline Study Phase 4  
[2020 Guidehouse Residential Baseline Phase 4](#)
  - 5 : Guidehouse (2021). Virtual Home Energy Assessment Study.  
[2021 Guidehouse VHEA Report FINAL](#)
  - 6 : Guidehouse (2021). RCD ISR Analysis. [2021 Guidehouse RCD ISR 2020 Analysis FINAL](#)
  - 3 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study.  
[2019 NMR APSMeteringReport Revised](#)
  - 4 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study.  
[2019 NMR APSMeteringReport Revised](#)
  - 7 : NMR Group, Inc. (2021). C&I Prescriptive and Custom NTG Omnibus Study  
[2021 NMR C&I Omnibus NTG](#)

### 3.89. Refrigeration - Case Motor Replacement

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-CMR     |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

Installation of electronically commutated motors (ECMs) in multi-deck and freestanding coolers and freezers, typically on the retail floor of convenience stores, liquor stores, and grocery stores.<sup>1</sup>

#### BCR Measure IDs:

| Measure Name                     | Core Initiative                           | BCR Measure ID |
|----------------------------------|-------------------------------------------|----------------|
| Case Motor Replacement           | C&I Existing Building Retrofit (CI_RETRO) | EC2a037        |
| Case Motor Replacement (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a156        |

#### Algorithms for Calculating Primary Energy Impact:

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

$$\Delta kWh_{Motor} = kW_{Motor} \times LRF \times Hours$$

$$\Delta kWh_{Heat} = \Delta kWh_{Motor} \times 0.28 \times Eff_{rs}$$

$$\Delta kW = \Delta kWh / 8760$$

Where:

$\Delta kWh_{Motor}$  = Energy savings due to increased efficiency of case motor

$\Delta kWh_{Heat}$  = Energy savings due to reduced heat from evaporator fans

$kW_{motor}$  = Metered load of case motor

LRF = Load reduction factor: 53% when shaded pole motors are replaced, 29% when PSC motors are replaced.<sup>2</sup>

Hours = Average runtime of case motors (8,500 hours)<sup>3</sup>

0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.

$Eff_{rs}$  = Efficiency of typical refrigeration system (1.6 kW/ton)<sup>4</sup>

$\Delta kW$  = Average demand savings

8,760 = Hours per year

#### Baseline Efficiency:

The baseline efficiency case is the existing case motor.

#### High Efficiency:

The high efficiency case is the replacement of the existing case motor with an ECM.

**Measure Life:**

This measure is determined to have an add on single baseline in retrofit scenarios.<sup>5 6</sup>

| Measure Name                           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - Case Motor Replacement | CI_RETRO        | All | 15  | 1   | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                           | Core Initiative | PA         | ISR  | RR <sub>E</sub> <sup>7</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------|-----------------|------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| Refrigeration - Case Motor Replacement | CI_RETRO        | ES, Unitil | 1.00 | 0.95                         | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration - Case Motor Replacement | CI_RETRO        | NGRID, CLC | 1.00 | 1.05                         | 1.00             | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

**Realization Rates:**

Values based on small business non-lighting study.<sup>8</sup>

**Coincidence Factors:**

Coincidence factors are representative of C&I Refrigeration

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>8</sup>

| Measure Name                                     | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Refrigeration - Case Motor Replacement           | CI_RETRO        | All | 0.18 | 0.00            | 0.05             | 0.88 |
| Refrigeration - Case Motor Replacement (Turnkey) | CI_RETRO        | All | 0.08 | 0.01            | 0.00             | 0.94 |

**Non-Energy Impacts:**

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>9</sup>

| Measure Name                           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - Case Motor Replacement | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

**Endnotes:**

- 1** : The assumptions and algorithms used in this section are specific to NRM products.
- 2** : Load factor is an estimate by NRM based on several pre- and post-meter readings of installations
- 3** : Conservative value based on 15 years of NRM field observations and experience.
- 4** : Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users’ Manual. Prepared for NSTAR.  
[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)
- 5** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.  
[2018 DNVGL ERS Portfolio Model Companion Sheet](#)
- 6** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations. [ERS 2005 Measure Life Study](#)
- 8** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures.  
[Final Report MA19C03-E-SBIMPCT 03202020](#)
- 8** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.  
[2021 NMR C&I Omnibus NTG](#)
- 9** : NMR Group, Inc. (2021). MA C&I O&M and non-O&M NEI Study.



### 3.90. Refrigeration - Door Heater Controls

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-DHC     |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

Installation of controls to reduce the run time of door and frame heaters for freezers and walk-in or reach-in coolers. The reduced heating results in a reduced cooling load.<sup>1</sup>

#### BCR Measure IDs:

| Measure Name                   | Core Initiative                           | BCR Measure ID |
|--------------------------------|-------------------------------------------|----------------|
| Door Heater Controls           | C&I Existing Building Retrofit (CI_RETRO) | EC2a034        |
| Door Heater Controls (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a153        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = kW_{DH} * \%OFF * 8760$$

$$\Delta kW = kW_{DH} * \%OFF$$

Where:

$kW_{DH}$  = Total demand of the door heater, calculated as Volts \* Amps / 1000

8760 = Door heater annual run hours before controls

%OFF Door heater Off time: 46% for freezer door heaters or 74% for cooler door heaters)<sup>2</sup>

#### Baseline Efficiency:

The baseline efficiency case is a cooler or freezer door heater that operates 8,760 hours per year without any controls.

#### High Efficiency:

The high efficiency case is a cooler or freezer door heater connected to a heater control system, which controls the door heaters by measuring the ambient humidity and temperature of the store, calculating the dew point, and using pulse width modulation (PWM) to control the anti-sweat heater based on specific algorithms for freezer and cooler doors. Door temperature is typically maintained about 5°F above the store air dew point temperature.<sup>3</sup>

#### Measure Life:

This measure was determined to have an add on single baseline for retrofit scenarios.<sup>4,5</sup>

| Measure Name                         | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - Door Heater Controls | CI_RETRO        | All | 10  | 1   | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                        | Core Initiative | PA                 | ISR  | RR <sub>E</sub> <sup>6</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-------------------------------------|-----------------|--------------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| Refrigeration -Door Heater Controls | CI_RETRO        | Eversource, Unutil | 1.00 | 0.95                         | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration -Door Heater Controls | CI_RETRO        | National Grid, CLC | 1.00 | 1.05                         | 1.00             | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in-service rates since all PAs’ programs include verification of equipment installations.

**Realization Rates:**

Values based on small business non-lighting study.<sup>7</sup>

**Coincidence Factors:**

Coincidence factors are representative of C&I Refrigeration

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>8</sup>

| Measure Name                         | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|--------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Refrigeration - Door Heater Controls | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |

**Non-Energy Impacts:**

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>9</sup>

| Measure Name                         | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - Door Heater Controls | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

---

**Endnotes:**

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- 1** : The assumptions and algorithms used in this section are specific to NRM products.
- 2** : The value is an estimate by NRM based on hundreds of downloads of hours of use data from Door Heater controllers. These values are also supported by Select Energy Services, Inc. (2004). Cooler Control Measure Impact Spreadsheet User's Manual. Prepared for NSTAR.  
[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)
- 3** : Select Energy Services, Inc. (2004). Analysis of Cooler Control Energy Conservation Measures. Prepared for NSTAR.  
[Select Energy 2004 Analysis of Cooler Control Energy Conservation Measures](#)
- 5** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)
- 7** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures. [Final Report MA19C03-E-SBIMPCT 03202020](#)
- 8** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.  
[2021 NMR C&I Omnibus NTG](#)
- 9** : MA20X10-B-CIOMNEI

### 3.91. Refrigeration - ECM Evaporator Fan Motors for Walk-in Cooler/Freezer

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-ECMEFM  |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

Installation of various sizes of electronically commutated motors (ECMs) in walk-in coolers and freezers to replace existing evaporator fan motors.<sup>1</sup>

#### BCR Measure IDs:

| Measure Name                                            | Core Initiative                           | BCR Measure ID |
|---------------------------------------------------------|-------------------------------------------|----------------|
| ECM Evaporator Fan Motors for Walk-in Coolers           | C&I Existing Building Retrofit (CI_RETRO) | EC2a036        |
| ECM Evaporator Fan Motors for Walk-in Coolers (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a155        |

#### Algorithms for Calculating Primary Energy Impact:

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

$$\Delta kWh_{Fan} = kW_{Fan} * LRF * Hours$$

$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$

$$\Delta kW = \Delta kWh / 8760$$

Where:

$\Delta kWh_{Fan}$  = Energy savings due to increased efficiency of evaporator fan motor

$\Delta kWh_{Heat}$  = Energy savings due to reduced heat from the evaporator fans

$kW_{Fan}$  = Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/adjustment<sup>2</sup> : Amps x Voltage x PF x  $\sqrt{\text{Phase}}$

LRF = Load reduction factor for motor replacement (65%)<sup>3</sup>

Hours = Annual fan operating hours.

0.28 = Conversion factor between kW and tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton

$Eff_{RS}$  = Efficiency of typical refrigeration system: 1.6 kW/ton<sup>4</sup>

$\Delta kW$  = Average demand savings

8,760 = Hours per year

#### Baseline Efficiency:

The baseline efficiency case is an existing evaporator fan motor.

**High Efficiency:**

The high efficiency case is the replacement of existing evaporator fan motors with ECMs.

**Measure Life:**

This measure is determined to be an add on single baseline measure for retrofit scenarios.<sup>5 6</sup>

| Measure Name                                                               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers | CI_RETRO        | All | 15  | 1   | n/a | 15  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                                                               | Core Initiative | PA                 | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> <sup>7</sup> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------------------------------------------|-----------------|--------------------|------|-----------------|-------------------------------|------------------|------------------|------------------|------------------|
| Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers | CI_RETRO        | Eversource, Unifil | 1.00 | 0.95            | 1.00                          | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers | CI_RETRO        | National Grid, CLC | 1.00 | 1.05            | 1.00                          | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

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

**Realization Rates:**

Values based on small business non-lighting study.<sup>8</sup>

**Coincidence Factors:**

Coincidence factors are representative of C&I Refrigeration

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>9</sup>

| Measure Name                                                               | Core Initiative | PA  | FR     | SO <sub>P</sub> | SO <sub>NP</sub> | NTG    |
|----------------------------------------------------------------------------|-----------------|-----|--------|-----------------|------------------|--------|
| Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers | CI_RETRO        | All | 13.50% | 5.30%           | 1.80%            | 93.50% |

## Non-Energy Impacts:

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>10</sup>

| Measure Name                                                               | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

## Endnotes:

**1** : The assumptions and algorithms used in this section are specific to NRM products.

**2** : Conservative value based on 15 years of NRM field observations and experience.

**3** : Load factor is an estimate by NRM based on several pre- and post-meter readings of installations; the value is supported by RLW Analytics (2007). Small Business Services Custom Measure Impact Evaluation. Prepared for National Grid.

[RLW 2007 Small Business Services Custom Measure Impact Evaluation](#)

**4** : Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users' Manual. Prepared for NSTAR.

[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)

**5** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.

[2018 DNVGL ERS Portfolio Model Companion Sheet](#)

**6** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations. [ERS 2005 Measure Life Study](#)

**8** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures.

[Final Report MA19C03-E-SBIMPCT 03202020](#)

**9** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.

[2021 NMR C&I Omnibus NTG](#)

**10** : MA20X10-B-CIOMNEI

### 3.92. Refrigeration - Electric Deck Oven

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | COM-R-EDO         |
| <b>Market</b>       | Commercial        |
| <b>Program Type</b> | Early Replacement |
| <b>Category</b>     | Refrigeration     |

#### BCR Measure IDs:

| Measure                        | Core Initiative                            | BCR Measure ID |
|--------------------------------|--------------------------------------------|----------------|
| Midstream - Electric Deck Oven | C&I New & Replacement Equipment (CI_EQUIP) | EC2b113        |

#### Algorithms for Calculating Primary Energy Impact:

$kWH = (\text{Daily energy consumption} * \text{Operating days per year} = \text{Annual Energy Consumption}(kWh))$

$\text{Annual Energy Consumption}(kWh) \text{ standard model} - \text{Annual Energy Consumption}(kWh) = \text{Energy savings } kWh/year.$

$kW = \text{Average Demand } kW * \text{Coincidence Factor}$

| Medium Tier Savings                    | Standard Model | Efficient Model |
|----------------------------------------|----------------|-----------------|
| Preheat Time (min)                     | 30             | 30              |
| Preheat Energy (kWh)                   | 6.50           | 3.00            |
| Deck Idle Energy Rate (kW)             | 1.90000        | 1.30000         |
| Deck Cooking-Energy Efficiency (%)     | 40%            | 60%             |
| Deck Production Capacity (lb/h)        | 60             | 60              |
| Operating Hours/Day                    | 12             | 12              |
| Operating Days/Year                    | 365            | 365             |
| Pounds of Food Cooked per Day          | 200            | 200             |
| ASTM Conv Mode Energy to Food (kWh/lb) | 0.0732         | 0.0732          |
| Deck Mode Energy (kWh/d)               | 52.1           | 35.0            |
| Daily Energy Consumption (kWh)         | 58.62          | 38.02           |

|                                   |           |           |
|-----------------------------------|-----------|-----------|
| Average Demand (kW)               | 4.88472   | 3.16806   |
| Coincidence Factor                | 0.90000   | 0.90000   |
| Estimated Demand Reduction (kW)   | --        | 1.54500   |
| Annual Energy Consumption (kWh)   | 21,395.08 | 13,876.08 |
| Estimated Energy Savings (kWh/yr) | --        | 7,519.00  |
| % Savings                         |           | 35%       |

Savings are deemed based on above algorithms.

| Measure            | Core Initiative | PA  | kWh   | kW    |
|--------------------|-----------------|-----|-------|-------|
| Electric Deck Oven | CI_EQUIP        | ALL | 7,519 | 1.545 |

**Baseline Efficiency:**

40% Efficiency & 1.9 kW idle energy rate <sup>1</sup>

**High Efficiency:**

Food Service Technology Center (FSTC) pre-approved list  
<https://caenergywise.com/rebates/>

**Other Resource Impacts:**

There are no other resource impact.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure            | Core Initiative | PA  | ISR  | SPF  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------|-----------------|-----|------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Electric Deck Oven | CI_EQUIP        | All | 1.00 | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.



**Impact Factors for Calculating Net Savings:**

All PA's use statewide NTG from study results <sup>3</sup>

| Measure            | Initiative | PA  | FR    | SO   | NPSO | NTG   |
|--------------------|------------|-----|-------|------|------|-------|
| Electric Deck Oven | CI_EQUIP   | All | 25.0% | 0.2% | 8.5% | 83.7% |

**Non-Energy Impacts:**

Non-energy impacts are based on study results<sup>4</sup>

| Measure Name       | PA  | Annual \$<br>per Unit | One-time \$<br>per Unit | Annual \$<br>per kWh | One-time \$<br>per kWh | Annual \$<br>per Therm | One-time\$<br>per Therm |
|--------------------|-----|-----------------------|-------------------------|----------------------|------------------------|------------------------|-------------------------|
| Electric Deck Oven | All | \$0.00                | \$0.00                  | \$0.00               | \$0.007                | 0.00                   | 0.00                    |

**Endnotes:**

1 : 2020 CA eTRM

3 : [2021 NMR C&I Omnibus NTG](#)

4 : MA20X10-B-CIOMNEI

### 3.93. Refrigeration - Electronic Defrost Control

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-EDC     |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

A control mechanism to skip defrost cycles when defrost is unnecessary.<sup>1</sup>

#### BCR Measure IDs:

| Measure Name                         | Core Initiative                           | BCR Measure ID |
|--------------------------------------|-------------------------------------------|----------------|
| Electronic Defrost Control           | C&I Existing Building Retrofit (CI_RETRO) | EC2a039        |
| Electronic Defrost Control (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a158        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh_{\text{Defrost}} = kW_{\text{Defrost}} \times \text{Hours} \times \text{DRF}$$

$$\Delta kWh_{\text{Heat}} = \Delta kWh_{\text{Defrost}} \times 0.28 \times \text{Eff}_{\text{RS}}$$

$$\Delta kWh = \Delta kWh_{\text{Defrost}} + \Delta kWh_{\text{Heat}}$$

$$\Delta kW = \Delta kWh / 8760$$

Where:

$\Delta kWh_{\text{Defrost}}$  = Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls.

$\Delta kWh_{\text{Heat}}$  = Energy savings due to reduced heat from reduced number of defrosts.

$kW_{\text{Defrost}}$  = Load of electric defrost.

Hours = Number of hours defrost occurs over a year without the defrost controls.

DRF = Defrost reduction factor- percent reduction in defrosts required per year (35%)<sup>2</sup>

0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.

$\text{Eff}_{\text{RS}}$  = Efficiency of typical refrigeration system (1.6 kW/ton)<sup>3</sup>

$\Delta kW$  = Average demand savings

8,760 = Hours per year

#### Baseline Efficiency:

The baseline efficiency case is an evaporator fan electric defrost system that uses a time clock mechanism to initiate defrost.

#### High Efficiency:

The high efficiency case is an evaporator fan defrost system with electric defrost controls.

**Measure Life:**

This measure is determined to have an add on single baseline in retrofit scenarios.<sup>4 5</sup>

| Measure Name                               | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - Electronic Defrost Control | CI_RETRO        | All | 10  | 1   | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                               | Core Initiative | PA                      | ISR  | RR <sub>E</sub> <sup>8</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------------------------------|-----------------|-------------------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| Refrigeration - Electronic Defrost Control | CI_RETRO        | Eversource<br>Unitil    | 1.00 | 0.95                         | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration - Electronic Defrost Control | CI_RETRO        | National<br>Grid<br>CLC | 1.00 | 1.05                         | 1.00             | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs’ programs include verification of equipment installations.

**Realization Rates:**

- Values based on small business non-lighting study (2019)

**Coincidence Factors:**

Coincidence factors are representative of C&I Refrigeration.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results.<sup>7</sup>

| Measure Name                               | Core Initiative | PA  | FR    | SOP  | SONP | NTG   |
|--------------------------------------------|-----------------|-----|-------|------|------|-------|
| Refrigeration - Electronic Defrost Control | CI_RETRO        | All | 13.5% | 5.3% | 1.8% | 93.5% |

**Non-Energy Impacts:**

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>8</sup>

| Measure Name                               | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - Electronic Defrost Control | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

**Endnotes:**

- 1** : The assumptions and algorithms used in this section are specific to NRM products.
- 2** : Supported by 3rd party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability.
- 3** : Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users’ Manual. Prepared for NSTAR.  
[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)
- 4** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.  
[2018 DNVGL ERS Portfolio Model Companion Sheet](#)
- 5** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities. [ERS 2005 Measure Life Study](#)
- 8** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures.  
[Final Report MA19C03-E-SBIMPCT 03202020](#)
- 7** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.  
[2021 NMR C&I Omnibus NTG](#)
- 8** : MA20X10-B-CIOMNEI

### 3.94. Refrigeration - Evaporator Fan Control

|                     |                  |
|---------------------|------------------|
| <b>Measure Code</b> | COM-R-EFC        |
| <b>Market</b>       | Commercial       |
| <b>Program Type</b> | New Construction |
| <b>Category</b>     | Refrigeration    |

#### Measure Description:

Installation of controls to modulate the evaporator fans based on temperature control. Energy savings include: fan energy savings from reduced fan operating hours, refrigeration energy savings from reduced waste heat, and compressor energy savings resulting from the electronic temperature control. Electronic controls allow less fluctuation in temperature, thereby creating savings.<sup>1</sup>

#### BCR Measure IDs:

| Measure Name                      | Core Initiative                           | BCR Measure ID |
|-----------------------------------|-------------------------------------------|----------------|
| Evaporator Fan Controls           | C&I Existing Building Retrofit (CI_RETRO) | EC2a040        |
| Evaporator Fan Controls (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a159        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat} + \Delta kWh_{Control}$$

$$\Delta kWh_{Fan} = kW_{Fan} * 8760 * \% OFF$$

$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$

$$\Delta kWh_{Control} = [kW_{CP} * Hours_{SCP} + kW_{Fan} * 8760 * (1 - \% OFF)] * 5\%$$

$$\Delta kW = \Delta kWh / 8760$$

Where :

- $\Delta kWh_{Fan}$  = Energy savings due to evaporator being shut off
- $\Delta kWh_{Heat}$  = Energy savings due to reduced heat from the evaporator fans
- $\Delta kWh_{Control}$  = Energy savings due to the electronic controls on compressor and evaporator
- $kW_{Fan}$  = Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/ adjustment<sup>2</sup> : Amps x Voltage x PF x  $\sqrt{Phase}$
- $\% OFF$  = Percent of annual hours that the evaporator is turned off: 46%<sup>3</sup>
- 0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
- $Eff_{RS}$  = Efficiency of typical refrigeration system: 1.6 kW/ton<sup>4</sup>
- $kW_{CP}$  = Total power demand of compressor motor and condenser fan calculated from equipment nameplate data and estimated 0.85 power factor<sup>5</sup> : Amps x Voltage x PF x  $\sqrt{Phase}$
- $Hours_{SCP}$  = Equivalent annual full load hours of compressor operation: 4,072 hours<sup>6</sup>
- 5% = Reduced run-time of compressor and evaporator due to electronic temperature controls<sup>7</sup>
- $\Delta kW$  = Average demand savings
- 8,760 = Hours per year

**Baseline Efficiency:**

The baseline efficiency case assumes evaporator fans that run 8,760 annual hours with no temperature control.

**High Efficiency:**

The high efficiency case is the use of an energy management system to control evaporator fan and compressor operation based on temperature.

**Measure Life:**

This measure is determined to have an add on single baseline for retrofit scenarios.<sup>8,9</sup>

| Measure Name                            | Core Initiative | PA  | EUL | OYF | RUL | AML |
|-----------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - Evaporator Fan Controls | CI_RETRO        | All | 10  | 1   | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                            | Core Initiative | PA                | ISR  | RR <sub>E</sub> <sup>10</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|-----------------------------------------|-----------------|-------------------|------|-------------------------------|------------------|------------------|------------------|------------------|------------------|
| Refrigeration - Evaporator Fan Controls | CI_RETRO        | Eversource Unital | 1.00 | 0.95                          | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration - Evaporator Fan Controls | CI_RETRO        | National Grid CLC | 1.00 | 1.05                          | 1.00             | 0.94             | 1.17             | 1.00             | 1.00             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

**Realization Rates:**

Values based on small business non-lighting study (2019)

**Coincidence Factors:**

CFs representative of C&I Refrigeration.

### Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.<sup>12</sup>

| Measure Name                            | Core Initiative | PA  | FR    | SO <sub>P</sub> | SO <sub>NP</sub> | NTG   |
|-----------------------------------------|-----------------|-----|-------|-----------------|------------------|-------|
| Refrigeration - Evaporator Fan Controls | CI_RETRO        | All | 13.5% | 5.3%            | 1.8%             | 93.5% |

### Non-Energy Impacts:

Prescriptive refrigeration measures in retrofit applications have an annual \$/kwh NEI.<sup>13</sup>

| Measure Name                            | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|-----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - Evaporator Fan Controls | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

### Endnotes:

- 1** : The assumptions and algorithms used in this section are specific to NRM products.
- 2** : Conservative value based on 15 years of NRM field observations and experience.
- 3** : The value is an estimate by NRM based on hundreds of downloads of hours of use data. These values are also supported by Select Energy Services, Inc. (2004). Cooler Control Measure Impact Spreadsheet User's Manual. Prepared for NSTAR  
[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)
- 4** : Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users' Manual. Prepared for NSTAR.  
[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)
- 5** : This value is an estimate by NRM based on hundreds of downloads of hours of use data from the electronic controller.
- 6** : Conservative value based on 15 years of NRM field observations and experience.
- 7** : Conservative estimate supported by less conservative values given by several utility-sponsored 3rd Party studies including: Select Energy Services, Inc. (2004). Analysis of Cooler Control Energy Conservation Measures. Prepared for NSTAR.  
[Select Energy 2004 Analysis of Cooler Control Energy Conservation Measures](#)
- 8** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.  
[2018 DNVGL ERS Portfolio Model Companion Sheet](#)
- 9** : Energy & Resource Solutions (2005). Measure Life Study. [ERS 2005 Measure Life Study](#)
- 11** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures.  
[Final Report MA19C03-E-SBIMPCT 03202020](#)
- 12** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.  
[2021 NMR C&I Omnibus NTG](#)
- 13** : MA20X10-B-CIOMNEI

### 3.95. Refrigeration - Hand Wrapper

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | COM-R-HR          |
| <b>Market</b>       | Commercial        |
| <b>Program Type</b> | Early Replacement |
| <b>Category</b>     | Refrigeration     |

#### BCR Measure IDs:

| Measure                  | Core Initiative                            | BCR Measure ID |
|--------------------------|--------------------------------------------|----------------|
| Midstream - Hand Wrapper | C&I New & Replacement Equipment (CI_EQUIP) | EC2b114        |

#### Algorithms for Calculating Primary Energy Impact:

Savings are deemed using the assumptions below:

| Measure Name | Core Initiative | PA  | kWh   | kW    |
|--------------|-----------------|-----|-------|-------|
| Hand Wrapper | CI_EQUIP        | ALL | 1,565 | 0.181 |

| Annual Energy  |                              |                              |                              |                              |                                    |
|----------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------------|
| Hand-Wrap Case | SUPERMARKET CHAIN 1 (kWh/yr) | SUPERMARKET CHAIN 2 (kWh/yr) | SUPERMARKET CHAIN 3 (kWh/yr) | SUPERMARKET CHAIN 4 (kWh/yr) | Annual Energy Consumption (kWh/yr) |
| Baseline       | 2,310.55                     | 1,809.70                     | 1,776.20                     | 1,983.14                     | 1,969.90                           |
| Efficient Case | 411.64                       | 395.10                       | 452.30                       | 361.21                       | 405.06                             |
| Annual Savings | 1898.91                      | 1414.60                      | 1323.90                      | 1621.93                      | 1564.84                            |
| Demand         |                              |                              |                              |                              |                                    |
| Hand-Wrap Case | SUPERMARKET CHAIN 1 (kW)     | SUPERMARKET CHAIN 2 (kW)     | SUPERMARKET CHAIN 3 (kW)     | SUPERMARKET CHAIN 4 (kW)     | Demand Savings (kW)                |
| Baseline       | 0.267                        | 0.227                        | 0.201                        | 0.229                        | 0.231                              |
| Efficient Case | 0.054                        | 0.043                        | 0.059                        | 0.043                        | 0.050                              |
| Annual Savings | 0.21                         | 0.18                         | 0.14                         | 0.19                         | 0.181                              |



**Baseline Efficiency:**

The baseline is a Commercial Electric Hand-wrap Machine Always On

**High Efficiency:**

On-demand Hand-wrap Machine with Mechanical or Optical Control System

**Measure Life:**

Measure life is 10 years per the 2020 CA eTRM

| Measure Name | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------|-----------------|-----|-----|-----|-----|-----|
| Hand Wrapper | CI_EQUIP        | All | 10  | n/a | n/a | 10  |

**Other Resource Impacts:**

There are no other Resource Impacts

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure          | Core Initiative | PA  | ISR  | SPF  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------|-----------------|-----|------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Conveyor Broiler | CI_EQUIP        | All | 1.00 | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

Net-to-gross assumptions are from study results<sup>1</sup>

| Measure      | Initiative | PA  | FR    | SO   | NPSO | NTG   |
|--------------|------------|-----|-------|------|------|-------|
| Hand Wrapper | CI_EQUIP   | All | 25.0% | 0.2% | 8.5% | 83.7% |

**Non-Energy Impacts:**

Non-energy Impacts are based on study results.<sup>2</sup>

| Measure Name | PA  | Annual \$<br>per Unit | One-time<br>\$ per Unit | Annual \$<br>per kWh | One-time \$<br>per kWh | Annual \$<br>per Therm | One-time\$<br>per Therm |
|--------------|-----|-----------------------|-------------------------|----------------------|------------------------|------------------------|-------------------------|
| Hand Wrapper | All | \$0.00                | \$0.00                  | \$0.00               | \$0.007                | 0.00                   | 0.00                    |

**Endnotes:**

1 : [2021 NMR C&I Omnibus NTG](#)

2 : MA20X10-B-CIOMNEI

### 3.96. Refrigeration - Lab-Grade Cold Storage

|                     |                   |
|---------------------|-------------------|
| <b>Measure Code</b> | COM-R-LGCS        |
| <b>Market</b>       | Commercial        |
| <b>Program Type</b> | Early Replacement |
| <b>Category</b>     | Refrigeration     |

#### BCR Measure IDs:

| Measure                            | Core Initiative                            | BCR Measure ID |
|------------------------------------|--------------------------------------------|----------------|
| Midstream - Lab-Grade Cold Storage | C&I New & Replacement Equipment (CI_EQUIP) | EC2b098        |

#### Algorithms for Calculating Primary Energy Impact:

Savings are deemed per the Covid Lab Equipment 2021 MA-RI Forecast by Percentage of Sales 012821 <sup>1</sup>

| Measure Name           | Core Initiative | PA  | kWh   | kW    |
|------------------------|-----------------|-----|-------|-------|
| Lab Grade Cold Storage | CI_EQUIP        | ALL | 2,910 | 0.332 |

#### Baseline Efficiency:

The baseline is 40% more energy use than ENERGY STAR unit provided in the Cold Storage Forecast Assumptions Word Document.

#### High Efficiency:

Eligible Equipment

| Equipment Category                                               | Eligibility                                 |
|------------------------------------------------------------------|---------------------------------------------|
| Laboratory Grade High Performance Refrigerators, 6≤V<25 cu. ft.  | $\leq 0.184*V + 3.5$ kWh/day, V=unit volume |
| Laboratory Grade High Performance Refrigerators, 25≤V<44 cu. ft. | $\leq 0.153*V + 4.28$ kWh/day               |
| Laboratory Grade High Performance Refrigerators, ≥44 cu. ft.     | $\leq 0.125*V + 5.5$ kWh/day                |
| Laboratory Grade High Performance Freezers, 6≤V<22 cu. ft.       | $\leq 0.09*V + 10$ kWh/day                  |
| Laboratory Grade High Performance Freezers, ≥22 cu. ft.          | $\leq 0.426*V + 2.63$ kWh/day               |
| Ultra Low Temperature Freezer (-80 C)                            | 0.55 kWh / cu. ft. / day                    |

**Measure Life:**

The Measure Life is 10 years per and Assumed value agreed upon with EEAC Consultants

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Lab Grade Cold Storage | CI_EQUIP        | All | 10  | 0   | n/a | 10  |

**Other Resource Impacts:**

There are no other Resource Impacts associated with this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                | Core Initiative | PA  | ISR  | SPF  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|-----------------|-----|------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Lab Grade Cold Storage | CI_EQUIP        | All | 1.00 | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed because savings are based on researched assumptions.

**Coincidence Factors:**

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

**Impact Factors for Calculating Net Savings:**

Net-to-Gross are based on study results. <sup>2</sup>

| Measure           | Initiative | PA  | FR    | SO   | NPSO | NTG   |
|-------------------|------------|-----|-------|------|------|-------|
| Lab Grade Storage | CI_EQUIP   | All | 25.0% | 0.2% | 8.5% | 83.7% |

**Non-Energy Impacts:**

| Measure Name      | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time\$ per Therm |
|-------------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|----------------------|
| Lab Grade Storage | All | \$0.00             | \$0.00               | \$0.001           | \$0.00              | 0.00                | 0.00                 |

**Endnotes:**

1 : [Covid Lab Equipment 2021 MA-RI Forecast by Percentage of Sales 012821](#)

2 : [2021 NMR C&I Omnibus NTG](#)

### 3.97. Refrigeration - Novelty Cooler Shutoff

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-NCS     |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

Installation of controls to shut off a facility’s novelty coolers for non-perishable goods based on pre-programmed store hours. Energy savings occur as coolers cycle off during facility unoccupied hours.<sup>1</sup>

#### BCR Measure IDs:

| Measure Name                     | Core Initiative                           | BCR Measure ID |
|----------------------------------|-------------------------------------------|----------------|
| Novelty Cooler Shutoff           | C&I Existing Building Retrofit (CI_RETRO) | EC2a035        |
| Novelty Cooler Shutoff (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a154        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = kW_{NC} * DC_{AVG} * Hours_{OFF}$$

$$\Delta kW = 0$$

Where:

$\Delta kW = 0$  since savings are assumed to occur during evening hours and are therefore not coincident with either summer or winter peak periods.

$kW_{NC}$  = Power demand of novelty cooler calculated from equipment nameplate data and estimated 0.85 power factor<sup>2</sup>

$Hours_{OFF}$  = Potential hours off every night per year, estimated as one less than the number of hours the store is closed per day

$DC_{AVG}$  = Weighted average annual duty cycle: 48.75%<sup>3</sup>

#### Baseline Efficiency:

The baseline efficiency case is the novelty coolers operating 8,760 hours per year.

#### High Efficiency:

The high efficiency case is the novelty coolers operating fewer than 8,760 hours per year since they are controlled to cycle each night based on pre-programmed facility unoccupied hours.

**Measure Life:**

This measure is determined to have an add on single baseline for retrofit scenarios.<sup>4 5</sup>

| Measure Name                           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|----------------------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigeration - Novelty Cooler Shutoff | CI_RETRO        | All | 10  | 1   | n/a | 10  |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name                           | Core Initiative | PA                | ISR  | RR <sub>E</sub> <sup>8</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|----------------------------------------|-----------------|-------------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| Refrigeration - Novelty Cooler Shutoff | CI_RETRO        | Eversource Unitil | 1.00 | 0.95                         | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| Refrigeration - Novelty Cooler Shutoff | CI Retro        | National Grid CLC | 1.00 | 1.05                         | 1.00             | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs' programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on study results.<sup>8</sup>

**Coincidence Factors:**

Coincidence factors representative of C&I Refrigeration.

**Impact Factors for Calculating Net Savings: ↓**

All PAs use statewide prescriptive net-to-gross results.<sup>7</sup>

| Measure Name                           | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| Refrigeration - Novelty Cooler Shutoff | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |

## Non-Energy Impacts:

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>8</sup>

| Measure Name                           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|----------------------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigeration - Novelty Cooler Shutoff | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

## Endnotes:

- 1** : The assumptions and algorithms used in this section are specific to NRM products
- 2** : Conservative value based on 15 years of NRM field observations and experience.
- 3** : The estimated duty cycles for Novelty Coolers are supported by Select Energy Services, Inc. (2004). Cooler Control Measure Impact Spreadsheet Users' Manual. Prepared for NSTAR. The study gives a less conservative value than used by NRM.  
[Select Energy 2004 Cooler Control Measure Impact Spreadsheet Users Manual](#)
- 4** : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo.  
[2018 DNVGL ERS Portfolio Model Companion Sheet](#)
- 5** : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1. [ERS 2005 Measure Life Study](#)
- 8** : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures.  
[Final Report MA19C03-E-SBIMPCT 03202020](#)
- 7** : NMR Group, Inc. (2021). Prescriptive and Custom NTG Omnibus Study.  
[2021 NMR C&I Omnibus NTG](#)
- 8** : MA20X10-B-CIOMNEI

### 3.98. Refrigeration - Refrigerated Chef Base

|                     |                              |
|---------------------|------------------------------|
| <b>Measure Code</b> | COM-R-RCB                    |
| <b>Market</b>       | Commercial                   |
| <b>Program Type</b> | Early Replacement            |
| <b>Category</b>     | Commercial Kitchen Equipment |

#### BCR Measure IDs:

| Measure                                     | Core Initiative                            | BCR Measure ID |
|---------------------------------------------|--------------------------------------------|----------------|
| Midstream - Refrigerated Chef Base, 35-54"  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b109        |
| Midstream - Refrigerated Chef Base, 55-73"  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b110        |
| Midstream - Refrigerated Chef Base, 74-89"  | C&I New & Replacement Equipment (CI_EQUIP) | EC2b111        |
| Midstream - Refrigerated Chef Base, 90-120" | C&I New & Replacement Equipment (CI_EQUIP) | EC2b112        |

#### Algorithms for Calculating Primary Energy Impact:

Chef Base Daily Energy Use kWh/day/ft3 \* 365 (# Of days) = Annual Energy Consumption (kWh)/ft3

(Annual Energy Consumption Standard - Annual Energy Consumption Efficient) x Refrigerated Volume = kWh/yr

(Peak demand Intensity kW/ft3 Standard - Efficient) x Refrigerated Volume = Peak Demand Savings kW

| Measure                         | Core Initiative | PA  | kWh   | kW     |
|---------------------------------|-----------------|-----|-------|--------|
| Refrigerated Chef Base, 35-54"  | CI_EQUIP        | ALL | 1,051 | 0.1152 |
| Refrigerated Chef Base, 55-73"  | CI_EQUIP        | ALL | 1,637 | 0.1770 |
| Refrigerated Chef Base, 74-89"  | CI_EQUIP        | ALL | 1,985 | 0.2142 |
| Refrigerated Chef Base, 90-120" | CI_EQUIP        | ALL | 2,673 | 0.2885 |

#### Baseline Efficiency:

Baseline Efficiency from the 2020 CA eTRM etrm<sup>1</sup>



|                                                                                              |
|----------------------------------------------------------------------------------------------|
| Exterior Length between 35 – 54 inches and Daily Energy Use Intensity of 0.6000 kWh/day/ft3  |
| Exterior Length between 55 – 73 inches and Daily Energy Use Intensity of 0.5400 kWh/day/ft3  |
| Exterior Length between 74 – 89 inches and Daily Energy Use Intensity of 0.4751 kWh/day/ft3  |
| Exterior Length between 90 – 120 inches and Daily Energy Use Intensity of 0.4700 kWh/day/ft3 |

**High Efficiency:**

Measure Eligibility/Qualifications <sup>2</sup>

|                                                                                             |
|---------------------------------------------------------------------------------------------|
| Exterior Length between 35 – 54 inches and Daily Energy Use Intensity <=0.1800 kWh/day/ft3  |
| Exterior Length between 55 – 73 inches and Daily Energy Use Intensity <=0.1600 kWh/day/ft3  |
| Exterior Length between 74 – 89 inches and Daily Energy Use Intensity <=0.1400 kWh/day/ft3  |
| Exterior Length between 90 – 120 inches and Daily Energy Use Intensity <=0.1400 kWh/day/ft3 |

**Measure Life:**

| Measure Name           | Core Initiative | PA  | EUL | OYF | RUL | AML |
|------------------------|-----------------|-----|-----|-----|-----|-----|
| Refrigerated Chef Base | CI_EQUIP        | All | 12  | n/a | n/a | 12  |

**Other Resource Impacts:**

There are no other Resource Impacts.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure                | Core Initiative | PA  | ISR  | SPF  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|------------------------|-----------------|-----|------|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Refrigerated Chef Base | CI_EQUIP        | All | 1.00 | 1.00 | 1.00            | n/a              | 1.00             | 1.00             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs’ programs include verification of equipment installations.

**Realization Rates:**

100% realization rates are assumed until evaluated

**Coincidence Factors:**

Coincidence factors are 0.0. for both summer and winter seasons.

**Impact Factors for Calculating Net Savings:**

All PA's use evaluated Statewide Results. <sup>3</sup>

| Measure                | Initiative | PA  | FR    | SO   | NPSO | NTG   |
|------------------------|------------|-----|-------|------|------|-------|
| Refrigerated Chef Base | CI_EQUIP   | All | 25.0% | 0.2% | 8.5% | 83.7% |

**Non-Energy Impacts:**

Non-energy Impacts are based on study results. <sup>4</sup>

| Measure Name           | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per kWh | Annual \$ per Therm | One-time \$ per Therm |
|------------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| Refrigerated Chef Base | CI_EQUIP        | ALL | \$0,00             | \$0,00               | \$0,00            | \$0,007             | \$0,00              | \$0.00                |

**Endnotes:**

- 1 : 2020 CA eTRM
- 2 : 2020 CA eTRM
- 3 : [2021 NMR C&I Omnibus NTG](#)
- 4 : MA20X10 -B-CIOMNEI

### 3.99. Refrigeration - Vending Miser

|                     |               |
|---------------------|---------------|
| <b>Measure Code</b> | COM-R-VM      |
| <b>Market</b>       | Commercial    |
| <b>Program Type</b> | Retrofit      |
| <b>Category</b>     | Refrigeration |

#### Measure Description:

Controls can significantly reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.

#### BCR Measure IDs:

| Measure Name                                                         | Core Initiative                           | BCR Measure ID |
|----------------------------------------------------------------------|-------------------------------------------|----------------|
| Vending Miser - Refrigerated Beverage Vending Machines               | C&I Existing Building Retrofit (CI_RETRO) | EC2a031        |
| Vending Miser - Non-Refrigerated Beverage Vending Machines           | C&I Existing Building Retrofit (CI_RETRO) | EC2a032        |
| Vending Miser - Glass Front Refrigerated Coolers                     | C&I Existing Building Retrofit (CI_RETRO) | EC2a033        |
| Vending Miser (Residential End Use)                                  | C&I Existing Building Retrofit (CI_RETRO) | EC2a107        |
| Vending Miser - Refrigerated Beverage Vending Machines (Turnkey)     | C&I Existing Building Retrofit (CI_RETRO) | EC2a160        |
| Vending Miser - Non-Refrigerated Beverage Vending Machines (Turnkey) | C&I Existing Building Retrofit (CI_RETRO) | EC2a161        |
| Vending Miser - Glass Front Refrigerated Coolers (Turnkey)           | C&I Existing Building Retrofit (CI_RETRO) | EC2a162        |

#### Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = (kW_{\text{rated}})(\text{Hours})(\text{SAVE})$$

$$\Delta kW = \Delta kWh / \text{Hours}$$

Where:

$kW_{\text{rated}}$  = Rated kW of connected equipment. See for default rated kW by connected equipment type.

Hours = Operating hours of the connected equipment: default of 8,760 hours  
 SAVE = Percent savings factor for the connected equipment. See table below for values.

**Vending Machine and Cooler Controls Savings Factors<sup>1</sup>**

| Equipment Type                          | kW <sub>rated</sub> | SAVE (%) | ΔkW   | ΔkWh |
|-----------------------------------------|---------------------|----------|-------|------|
| Refrigerated Beverage Vending Machines  | 0.40                | 46       | 0.184 | 1612 |
| Non-Refrigerated Snack Vending Machines | 0.085               | 46       | 0.039 | 343  |
| Glass Front Refrigerated Coolers        | 0.46                | 30       | 0.138 | 1208 |

**Baseline Efficiency:**

The baseline efficiency case is a standard efficiency refrigerated beverage vending machine, nonrefrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**High Efficiency:**

The high efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**Measure Life:**

This measure is determined to be an add on single baseline measure for retrofit scenarios.<sup>2</sup>

| Measure Name       | Core Initiative | PA  | EUL | OYF | RUL | AML |
|--------------------|-----------------|-----|-----|-----|-----|-----|
| All Vending Misers | CI_RETRO        | All | 5   | 1   | n/a | 5   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure Name       | Core Initiative | PA                   | ISR  | RR <sub>E</sub> <sup>8</sup> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|--------------------|-----------------|----------------------|------|------------------------------|------------------|------------------|------------------|------------------|------------------|
| All Vending Misers | CI_RETRO        | National Grid Unutil | 1.00 | 0.95                         | 1.00             | 1.27             | 1.42             | 0.90             | 0.90             |
| All Vending Misers | CI_RETRO        | Eversource CLC       | 1.00 | 1.05                         | 1.00             | 0.94             | 1.17             | 0.90             | 0.90             |

**In-Service Rates:**

All installations have 100% in service rate since all PAs’ programs include verification of equipment installations.

**Realization Rates:**

Realization rates are based on study results.<sup>8</sup>

**Coincidence Factors:**

CFs based on staff estimates- assumed that savings occur during off peak hours.

**Impact Factors for Calculating Net Savings:**

All PAs use statewide prescriptive net-to-gross results for non-residential end uses.<sup>4</sup> PAs use results from a multi family evaluation for the residential end use.<sup>5</sup>

| Measure Name                                 | Core Initiative | PA  | FR   | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|----------------------------------------------|-----------------|-----|------|-----------------|------------------|------|
| All Vending Misers - Non-Residential end use | CI_RETRO        | All | 0.14 | 0.05            | 0.02             | 0.94 |
| Vending Miser (Residential End Use)          | CI_RETRO        | All | 0.21 | 0.13            | 0.17             | 1.09 |

**Non-Energy Impacts:**

Prescriptive refrigeration measures in retrofit applications have an annual \$/kWh NEI.<sup>7</sup>

| Measure Name       | Core Initiative | PA  | Annual \$ per Unit | One-time \$ per Unit | Annual \$ per kWh | One-time \$ per KWh | Annual \$ per Therm | One-time \$ per Therm |
|--------------------|-----------------|-----|--------------------|----------------------|-------------------|---------------------|---------------------|-----------------------|
| All Vending Misers | CI_RETRO        | All |                    |                      | \$0.001           |                     |                     |                       |

**Endnotes:**

- 1 : USA Technologies Energy Management Product Sheets (2006). [USA Tech 2006 Energy Management Product Sheets](#)
- 2 : Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet.. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo. [2018 DNVGL ERS Portfolio Model Companion Sheet](#)
- 8 : DNV GL. (2019). Impact Evaluation of PY 2017 Small Business Initiative Non-lighting measures. [Final Report MA19C03-E-SBIMPCT 03202020](#)
- 4 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. [2018 NMR CI FR-SO Report](#)
- 5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. [2018 Navigant Multifamily Program Impact Evaluation](#)
- 7 : MA20X10-B-CIOMNEI

### 3.100. Whole Building - C&I Metered Residential New Construction

|                     |                                                                   |
|---------------------|-------------------------------------------------------------------|
| <b>Measure Code</b> | COM-BE-RNC                                                        |
| <b>Market</b>       | Commercial                                                        |
| <b>Program Type</b> | New Construction                                                  |
| <b>Category</b>     | Heating Ventilation and Air Conditioning, Lighting, Water Heating |

#### BCR Measure IDs:

| Measure                                   | Core Initiative                                  | BCR Measure ID |
|-------------------------------------------|--------------------------------------------------|----------------|
| Multifamily Heating (High Rise)           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a056        |
| Multifamily Cooling (High Rise)           | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a057        |
| Multifamily Water Heating (High Rise)     | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a058        |
| Multifamily Lighting (High Rise)          | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a059        |
| Multifamily Heating (Passive House)       | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a060        |
| Multifamily Cooling (Passive House)       | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a061        |
| Multifamily Water Heating (Passive House) | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a062        |
| Multifamily Lighting (Passive House)      | C&I New Buildings & Major Renovations (CI_NB&MR) | EC1a063        |
| Heating (High Rise)                       | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a036        |
| Cooling (High Rise)                       | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a037        |
| Water Heating (High Rise)                 | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a038        |
| Lighting (High Rise)                      | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a039        |
| Heating (Passive House)                   | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a040        |

|                               |                                                  |         |
|-------------------------------|--------------------------------------------------|---------|
| Cooling (Passive House)       | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a041 |
| Water Heating (Passive House) | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a042 |
| Lighting (Passive House)      | C&I New Buildings & Major Renovations (CI_NB&MR) | GC1a043 |

### Algorithms for Calculating Primary Energy Impact:

Savings are derived from two modeling pathways within this initiative: the Low-Rise Performance Path, and the Multifamily High-Rise Performance Path.

The Program Administrators currently use vendor calculated energy savings for Low-Rise Performance Path projects. These savings are calculated using a RESNET accredited Rating Software Tool (Ekotrope) where a user inputs a detailed set of technical data about a project, comparing as-built projected energy consumption to that of a baseline home, the User-Defined Reference Home (UDRH). This process is used to calculate electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes, both single family and multifamily buildings (three stories and below).

For homes participating in the Multifamily High-Rise Path, the vendor models savings using a proprietary software. The software models the consumption of the as-built efficient building and compares that consumption to an architecturally similar building with baseline efficient equipment. The difference in consumption yields Heating, Cooling, Water Heating, and Lighting savings.

| Measure       | kW-per-kWh |
|---------------|------------|
| Heating       | 0.00073    |
| Cooling       | 0.00143    |
| Water Heating | 0.00025    |
| Lighting      | 0.00025    |

### Baseline Efficiency:

The User-Defined Reference Home (UDRH) is used for low-rise projects. It was updated in early 2020.<sup>1</sup>

The Multifamily High-Rise baseline is evaluated separately.<sup>2</sup>

Starting in 2020, renovation project savings use an Industry Standard Practice (ISP) baseline, per the recommendation provided by NMR in the R&A Market Characterization Study.<sup>3</sup>

**High Efficiency:**

The high-efficiency case is represented by the specific energy characteristics of each “as-built” home completed through the program.

**Measure Life:**

| Measure Name  | Core Initiative | PA  | EUL | OYF | RUL | AML |
|---------------|-----------------|-----|-----|-----|-----|-----|
| Heating       | CI_NB&MR        | All | 25  | n/a | n/a | 25  |
| Cooling       | CI_NB&MR        | All | 25  | n/a | n/a | 25  |
| Water Heating | CI_NB&MR        | All | 15  | n/a | n/a | 15  |
| Lighting      | CI_NB&MR        | All | 1   | n/a | n/a | 1   |

**Other Resource Impacts:**

There are no other resource impacts identified for this measure.

**Impact Factors for Calculating Adjusted Gross Savings:**

| Measure       | Core Initiative | PA  | ISR  | RR <sub>E</sub> | RR <sub>NE</sub> | RR <sub>SP</sub> | RR <sub>WP</sub> | CF <sub>SP</sub> | CF <sub>WP</sub> |
|---------------|-----------------|-----|------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Heating       | CI_NB&MR        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.00             | 0.43             |
| Cooling       | CI_NB&MR        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.50             | 0.04             |
| Water Heating | CI_NB&MR        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.15             | 0.42             |
| Lighting      | CI_NB&MR        | All | 1.00 | 1.00            | 1.00             | 1.00             | 1.00             | 0.19             | 0.35             |

**In-Service Rates:**

All installations have 100% in-service rate because all PA programs include verification of equipment installations.

**Realization Rates:**

Realization rates are 100% because energy and demand savings are custom-calculated based on project-specific detail.

**Coincidence Factors:**

Coincidence factors are based on prescriptive loadshapes from the updated Navigant Demand Impact Model.<sup>4</sup> National Grid uses custom calculated coincidence factors based on vendor-calculated project-specific detail.

**Impact Factors for Calculating Net Savings:**

Net to gross factors are based on evaluation results.<sup>5</sup>



| Measure Name      | Core Initiative | PA  | FR  | SO <sub>P</sub> | SO <sub>NP</sub> | NTG  |
|-------------------|-----------------|-----|-----|-----------------|------------------|------|
| RNC High Rise     | CI_NB&MR        | All | n/a | n/a             | n/a              | 0.83 |
| RNC Passive House | CI_NB&MR        | All | n/a | n/a             | n/a              | 0.90 |

### Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B. The heating values are applied based on the home's primary heating fuel.

| Measure Name | Core Initiative | PA  | Annual \$/Unit | One-time \$/Unit | Annual \$/kWh | One-time \$/KWh | Annual \$/Therm | One-time \$/Therm |
|--------------|-----------------|-----|----------------|------------------|---------------|-----------------|-----------------|-------------------|
| Heating      | CI_NB&MR        | All | \$139.00       |                  |               |                 |                 |                   |

### Endnotes:

5 : NMR Group, Inc. (2021). Non Residential New Construction NTG Report. [2021 NMR Non Residential New Construction NTG Report DRAFT](#)

# Appendices

## Appendix A: Common Lookup Tables

**Table A-1: Lighting Power Densities Using the Building Area Method<sup>3</sup>**

| Building Type               | 2018 IECC LPD (W/ft <sup>2</sup> ) | 2018 IECC w/ MA enhancements LPD (W/ft <sup>2</sup> ) |
|-----------------------------|------------------------------------|-------------------------------------------------------|
| Automotive Facility         | 0.71                               | 0.75                                                  |
| Convention Center           | 0.76                               | 0.64                                                  |
| Courthouse                  | 0.9                                | 0.79                                                  |
| Dining: bar lounge/leisure  | 0.9                                | 0.8                                                   |
| Dining: cafeteria/fast food | 0.79                               | 0.76                                                  |
| Dining: family              | 0.78                               | 0.71                                                  |
| Dormitory                   | 0.61                               | 0.53                                                  |
| Exercise center             | 0.65                               | 0.72                                                  |
| Fire station                | 0.53                               | 0.56                                                  |
| Gymnasium                   | 0.68                               | 0.76                                                  |
| Health care clinic          | 0.82                               | 0.81                                                  |
| Hospital                    | 1.05                               | 0.96                                                  |
| Hotel/Motel                 | 0.75                               | 0.56                                                  |
| Laboratory in a Classroom   | 1.2                                | 1.11                                                  |
| Laboratory Otherwise        | 1.45                               | 1.33                                                  |
| Library                     | 0.78                               | 0.83                                                  |
| Manufacturing facility      | 0.9                                | 0.82                                                  |
| Motion picture theater      | 0.83                               | 0.44                                                  |
| Multifamily                 | 0.68                               | 0.45                                                  |
| Museum                      | 1.06                               | 0.55                                                  |
| Office                      | 0.79                               | 0.64                                                  |
| Parking garage              | 0.15                               | 0.18                                                  |
| Penitentiary                | 0.75                               | 0.69                                                  |

<sup>3</sup> IECC 2018 Interior Lighting Power Allowances: Building Area method, adapted from Table C405.3.2(1) with adjustments for MA code enhancements

| <b>Building Type</b>    | <b>2018 IECC LPD (W/ft<sup>2</sup>)</b> | <b>2018 IECC w/ MA enhancements LPD (W/ft<sup>2</sup>)</b> |
|-------------------------|-----------------------------------------|------------------------------------------------------------|
| Performing arts theater | 1.18                                    | 0.84                                                       |
| Police station          | 0.8                                     | 0.66                                                       |
| Post office             | 0.67                                    | 0.65                                                       |
| Religious               | 0.94                                    | 0.67                                                       |
| Retail                  | 1.06                                    | 0.84                                                       |
| School/university       | 0.81                                    | 0.72                                                       |
| Sports arena            | 0.87                                    | 0.76                                                       |
| Town hall               | 0.8                                     | 0.69                                                       |
| Transportation          | 0.61                                    | 0.5                                                        |
| Warehouse               | 0.48                                    | 0.45                                                       |
| Workshop                | 0.9                                     | 0.91                                                       |

**Table A-2: Interior Lighting Power Allowances: Space-by-Space Method<sup>4</sup>**

| <b><u>Common Space Types</u></b>                  | <b><u>LPD Allowances, W/ft<sup>2</sup></u></b> |
|---------------------------------------------------|------------------------------------------------|
| <b>Atrium</b>                                     |                                                |
| <20 ft in height                                  | 0.03/ft total height                           |
| ≥20 ft and ≥40 ft in height                       | 0.03/ft total height                           |
| >40 ft in height                                  | 0.40 + 0.02/ft total height                    |
| <b>Audience Seating Area</b>                      |                                                |
| Auditorium                                        | 0.63                                           |
| Convention center                                 | 0.82                                           |
| Gymnasium                                         | 0.65                                           |
| Motion picture theater                            | 1.14                                           |
| Penitentiary                                      | 0.28                                           |
| Performing arts theater                           | 2.03                                           |
| Religious facility                                | 1.53                                           |
| Sports arena                                      | 0.43                                           |
| All other audience seating areas                  | 0.43                                           |
| <b>Banking Activity Area</b>                      | 0.86                                           |
| <b>Breakroom (See Lounge/Breakroom)</b>           |                                                |
| <b>Classroom/Lecture Hall/Training Room</b>       |                                                |
| Penitentiary                                      | 1.34                                           |
| All other classrooms/lecture halls/training rooms | 0.92                                           |
| <b>Conference/Meeting/Multipurpose Room</b>       | 1.07                                           |
| <b>Confinement Cells</b>                          | 0.81                                           |
| <b>Copy/Print Room</b>                            | 0.56                                           |

<sup>4</sup> IECC 2018 Interior Lighting Power Allowances: Space-by-Space Method, Table C405.3.2(2)

| <b><u>Common Space Types</u></b>                                                      | <b><u>LPD Allowances, W/ft<sup>2</sup></u></b> |
|---------------------------------------------------------------------------------------|------------------------------------------------|
| <b>Corridor<sup>2</sup></b>                                                           |                                                |
| Facility for the visually impaired (and not used primarily by the staff) <sup>3</sup> | 0.92                                           |
| Hospital                                                                              | 0.92                                           |
| Manufacturing facility                                                                | 0.29                                           |
| All other corridors                                                                   | 0.66                                           |
| <b>Courtroom</b>                                                                      | 1.39                                           |
| Computer Room                                                                         | 1.33                                           |
| <b>Dining Area</b>                                                                    |                                                |
| Penitentiary                                                                          | 0.96                                           |
| Facility for the visually impaired (and not used primarily by staff) <sup>3</sup>     | 2                                              |
| Bar/lounge or leisure dining                                                          | 0.93                                           |
| Cafeteria or fast food dining                                                         | 0.63                                           |
| Family dining                                                                         | 0.71                                           |
| All other dining areas                                                                | 0.63                                           |
| <b>Electrical/Mechanical Room<sup>7</sup></b>                                         | 0.43                                           |
| <b>Emergency Vehicle Garage</b>                                                       | 0.41                                           |
| <b>Food Preparation Area</b>                                                          | 1.06                                           |
| <b>Guest Room</b>                                                                     | 0.77                                           |
| <b>Laboratory</b>                                                                     |                                                |
| In or as a classroom                                                                  | 1.2                                            |
| All other laboratories                                                                | 1.45                                           |
| <b>Laundry/Washing Area</b>                                                           | 0.43                                           |
| <b>Loading Dock, Interior</b>                                                         | 0.58                                           |
| <b>Lobby</b>                                                                          |                                                |

| <b><u>Common Space Types</u></b>                                                      | <b><u>LPD Allowances, W/ft2</u></b> |
|---------------------------------------------------------------------------------------|-------------------------------------|
| Facility for the visually impaired (and not used primarily by the staff) <sup>3</sup> | 2.03                                |
| Elevator                                                                              | 0.69                                |
| Hotel                                                                                 | 1.06                                |
| Motion picture theater                                                                | 0.45                                |
| Performing arts theater                                                               | 1.7                                 |
| All other lobbies                                                                     | 1                                   |
| <b>Locker Room</b>                                                                    | 0.48                                |
| <b>Lounge/Breakroom</b>                                                               |                                     |
| Healthcare facility                                                                   | 0.78                                |
| All other lounges/breakrooms                                                          | 0.62                                |
| <b>Office</b>                                                                         |                                     |
| Enclosed and $\leq 250$ ft <sup>2</sup>                                               | 0.93                                |
| Enclosed and $> 250$ ft <sup>2</sup>                                                  | 0.93                                |
| Open plan                                                                             | 0.81                                |
| <b>Parking Area, Interior</b>                                                         | 0.14                                |
| <b>Pharmacy Area</b>                                                                  | 1.34                                |
| <b>Restroom</b>                                                                       |                                     |
| Facility for the visually impaired (and not used primarily by the staff) <sup>3</sup> | 0.96                                |
| All other restrooms                                                                   | 0.85                                |
| <b>Sales Area<sup>4</sup></b>                                                         | 1.22                                |
| <b>Seating Area, General</b>                                                          | 0.42                                |

| <b><u>Common Space Types</u></b>                                     | <b><u>LPD Allowances, W/ft<sup>2</sup></u></b>                                                                            |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>Stairway</b>                                                      | The <i>space</i> containing the stairway shall determine the <i>LPD</i> and <i>control</i> requirements for the stairway. |
| <b>Stairwell</b>                                                     | 0.58                                                                                                                      |
| <b>Storage Room</b>                                                  |                                                                                                                           |
| <50 ft <sup>2</sup>                                                  | 0.97                                                                                                                      |
| ≥50 ft <sup>2</sup> and ≤ 1000 ft <sup>2</sup>                       | 0.46                                                                                                                      |
| All other storage rooms                                              | 0.46                                                                                                                      |
| <b>Vehicular Maintenance Area</b>                                    | 0.56                                                                                                                      |
| Workshop                                                             | 1.14                                                                                                                      |
| <b>Facility for the Visually Impaired<sup>3</sup></b>                |                                                                                                                           |
| Chapel (used primarily by residents)                                 | 1.06                                                                                                                      |
| Recreation room/common living room (and not used primarily by staff) | 1.8                                                                                                                       |
| <b>Automotive (See "Vehicular Maintenance Area")</b>                 |                                                                                                                           |
| Convention Center—Exhibit Space                                      | 0.88                                                                                                                      |
| <b>Dormitory—Living Quarters</b>                                     | 0.54                                                                                                                      |
| <b>Fire Station—Sleeping Quarters</b>                                | 0.2                                                                                                                       |
| <b>Gymnasium/Fitness Center</b>                                      |                                                                                                                           |
| Exercise area                                                        | 0.5                                                                                                                       |
| Playing area                                                         | 0.82                                                                                                                      |
| <b>Healthcare Facility</b>                                           |                                                                                                                           |
| Exam/treatment room                                                  | 1.68                                                                                                                      |
| Imaging room                                                         | 1.06                                                                                                                      |

| <b><u>Common Space Types</u></b>                     | <b><u>LPD Allowances, W/ft<sup>2</sup></u></b> |
|------------------------------------------------------|------------------------------------------------|
| Medical supply room                                  | 0.54                                           |
| Nursery                                              | 1                                              |
| Nurse's station                                      | 0.81                                           |
| Operating room                                       | 2.17                                           |
| Patient room                                         | 0.62                                           |
| Physical therapy room                                | 0.84                                           |
| Recovery room                                        | 1.03                                           |
| <b>Library</b>                                       |                                                |
| Reading area                                         | 0.82                                           |
| Stacks                                               | 1.2                                            |
| <b>Manufacturing Facility</b>                        |                                                |
| Detailed manufacturing area                          | 0.93                                           |
| Equipment room                                       | 0.65                                           |
| Extra high bay area (>50 ft floor-to-ceiling height) | 1.05                                           |
| High bay area (25 to 50 ft floor-to-ceiling height)  | 0.75                                           |
| Low bay area (<25 ft floor-to-ceiling height)        | 0.96                                           |
| <b>Museum</b>                                        |                                                |
| General exhibition area                              | 1.05                                           |
| Restoration room                                     | 0.85                                           |
| <b>Performing Arts Theater—Dressing Room</b>         | 0.36                                           |
| <b>Post Office—Sorting Area</b>                      | 0.68                                           |
| <b>Religious Facility</b>                            |                                                |
| Fellowship hall                                      | 0.55                                           |



| <b><u>Common Space Types</u></b>             | <b><u>LPD Allowances, W/ft<sup>2</sup></u></b> |
|----------------------------------------------|------------------------------------------------|
| Worship/pulpit/choir area                    | 1.53                                           |
| <b>Retail Facilities</b>                     |                                                |
| Dressing/fitting room                        | 0.5                                            |
| Mall concourse                               | 0.9                                            |
| <b>Sports Arena—Playing Area<sup>8</sup></b> |                                                |
| Class I facility                             | 2.47                                           |
| Class II facility                            | 1.96                                           |
| Class III facility                           | 1.7                                            |
| Class IV facility                            | 1.13                                           |
| <b>Transportation Facility</b>               |                                                |
| Baggage/carousel area                        | 0.45                                           |
| Airport concourse                            | 0.31                                           |
| Terminal ticket counter                      | 0.62                                           |
| <b>Warehouse—Storage Area</b>                |                                                |
| Medium to bulky, palletized items            | 0.35                                           |
| Smaller, hand-carried items <sup>5</sup>     | 0.69                                           |

**C405.4.2.1 Building Area Method.**

For the Building Area Method, the interior lighting power allowance is the floor area for each building area type listed in Table C405.4.2(1) times the value from Table C405.4.2(1) for that area. For the purposes of this method, an “area” shall be defined as all contiguous spaces that accommodate or are associated with a single building area type, as listed in Table C405.4.2(1). Where this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area.

**C405.4.2.2 Space-by-Space Method.**

For the Space-by-Space Method, the interior lighting power allowance is determined by multiplying the floor area of each space times the value for the space type in Table C405.4.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Trade-offs among spaces are permitted.

**Table A-3: Mass Save New Construction Proposed Lighting Wattage Tables**

2018 Mass Save C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

| Device Code                  | Device Description | Rated Watts |
|------------------------------|--------------------|-------------|
| <i>LED Lighting Fixtures</i> |                    |             |
| 1L002                        | 2 WATT LED         | 2           |
| 1L003                        | 3 WATT LED         | 3           |
| 1L004                        | 4 WATT LED         | 04          |
| 1L005                        | 5 WATT LED         | 05          |
| 1L006                        | 6 WATT LED         | 06          |
| 1L007                        | 7 WATT LED         | 07          |
| 1L008                        | 8 WATT LED         | 08          |
| 1L009                        | 9 WATT LED         | 09          |
| 1L010                        | 10 WATT LED        | 10          |
| 1L011                        | 11 WATT LED        | 11          |
| 1L012                        | 12 WATT LED        | 12          |
| 1L013                        | 13 WATT LED        | 13          |
| 1L014                        | 14 WATT LED        | 14          |
| 1L015                        | 15 WATT LED        | 15          |
| 1L016                        | 16 WATT LED        | 16          |
| 1L017                        | 17 WATT LED        | 17          |
| 1L018                        | 18 WATT LED        | 18          |
| 1L019                        | 19 WATT LED        | 19          |
| 1L020                        | 20 WATT LED        | 20          |
| 1L021                        | 21 WATT LED        | 21          |
| 1L022                        | 22 WATT LED        | 22          |
| 1L023                        | 23 WATT LED        | 23          |
| 1L024                        | 24 WATT LED        | 24          |
| 1L025                        | 25 WATT LED        | 25          |
| 1L026                        | 26 WATT LED        | 26          |

| Device Code | Device Description | Rated Watts |
|-------------|--------------------|-------------|
| 1L027       | 27 WATT LED        | 27          |
| 1L028       | 28 WATT LED        | 28          |
| 1L029       | 29 WATT LED        | 29          |
| 1L030       | 30 WATT LED        | 30          |
| 1L031       | 31 WATT LED        | 31          |
| 1L032       | 32 WATT LED        | 32          |
| 1L033       | 33 WATT LED        | 33          |
| 1L034       | 34 WATT LED        | 34          |
| 1L035       | 35 WATT LED        | 35          |
| 1L036       | 36 WATT LED        | 36          |
| 1L037       | 37 WATT LED        | 37          |
| 1L038       | 38 WATT LED        | 38          |
| 1L039       | 39 WATT LED        | 39          |
| 1L040       | 40 WATT LED        | 40          |
| 1L041       | 41 WATT LED        | 41          |
| 1L042       | 42 WATT LED        | 42          |
| 1L043       | 43 WATT LED        | 43          |
| 1L044       | 44 WATT LED        | 44          |
| 1L045       | 45 WATT LED        | 45          |
| 1L046       | 46 WATT LED        | 46          |
| 1L047       | 47 WATT LED        | 47          |
| 1L048       | 48 WATT LED        | 48          |
| 1L049       | 49 WATT LED        | 49          |
| 1L050       | 50 WATT LED        | 50          |
| 1L053       | 53 WATT LED        | 53          |
| 1L055       | 55 WATT LED        | 55          |

| Device Code | Device Description | Rated Watts |
|-------------|--------------------|-------------|
| 1L060       | 60 WATT LED        | 60          |
| 1L063       | 63 WATT LED        | 63          |
| 1L071       | 71 WATT LED        | 71          |
| 1L070       | 70 WATT LED        | 70          |
| 1L073       | 73 WATT LED        | 73          |
| 1L075       | 75 WATT LED        | 75          |
| 1L080       | 80 WATT LED        | 90          |
| 1L085       | 85 WATT LED        | 85          |
| 1L090       | 90 WATT LED        | 90          |
| 1L095       | 95 WATT LED        | 95          |
| 1L100       | 100 WATT LED       | 100         |
| 1L101       | 101 WATT LED       | 101         |
| 1L106       | 106 WATT LED       | 106         |
| 1L107       | 107 WATT LED       | 107         |
| 1L116       | 116 WATT LED       | 116         |
| 1L120       | 120 WATT LED       | 120         |
| 1L125       | 125 WATT LED       | 125         |
| 1L130       | 130 WATT LED       | 130         |
| 1L131       | 131 WATT LED       | 131         |
| 1L135       | 135 WATT LED       | 135         |
| 1L139       | 139 WATT LED       | 139         |
| 1L140       | 140 WATT LED       | 140         |
| 1L145       | 145 WATT LED       | 145         |

| Device Code | Device Description | Rated Watts |
|-------------|--------------------|-------------|
| 1L150       | 150 WATT LED       | 150         |
| 1L155       | 155 WATT LED       | 155         |
| 1L160       | 160 WATT LED       | 160         |
| 1L164       | 164 WATT LED       | 164         |
| 1L165       | 165 WATT LED       | 165         |
| 1L170       | 170 WATT LED       | 170         |
| 1L175       | 175 WATT LED       | 175         |
| 1L180       | 180 WATT LED       | 180         |
| 1L185       | 185 WATT LED       | 185         |
| 1L186       | 186 WATT LED       | 186         |
| 1L190       | 190 WATT LED       | 190         |
| 1L200       | 200 WATT LED       | 200         |
| 1L204       | 204 WATT LED       | 204         |
| 1L205       | 205 WATT LED       | 205         |
| 1L210       | 210 WATT LED       | 210         |
| 1L211       | 211 WATT LED       | 211         |
| 1L220       | 220 WATT LED       | 220         |
| 1L233       | 233 WATT LED       | 233         |
| 1L235       | 235 WATT LED       | 235         |
| 1L237       | 237 WATT LED       | 237         |
| 1L240       | 240 WATT LED       | 240         |
| 1L256       | 256 WATT LED       | 256         |
| 1L279       | 279 WATT LED       | 279         |

**Table A-4: Mass Save Retrofit Existing/Proposed Lighting Wattage Tables**

2016 Mass Save C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

| Device Code           | Device Description | Rated Watts |
|-----------------------|--------------------|-------------|
| <i>LED Exit Signs</i> |                    |             |
| 1E0002                | 2.0 WATT LED       | 2           |
| 1E0003                | 3.0 WATT LED       | 3           |
| 1E0005                | 5.0 WLED           | 5           |
| 1E0005C               | 0.5 WATT LEC       | 0.5         |
| 1E0008                | 8.0 WLED           | 8           |
| 1E0015                | 1.5 WATT LED       | 1.5         |
| 1E0105                | 10.5 WATT LED      | 10.5        |
| <i>T5 Systems</i>     |                    |             |
| 1F14SSE               | 1L2' 14W T5/ELIG   | 16          |
| 1F21SSE               | 1L3' 21W T5/ELIG   | 24          |
| 1F24HSE               | 1L2' 24W T5HO/ELIG | 29          |
| 1F28SSE               | 1L4' 28W T5/ELIG   | 32          |
| 1F39HSE               | 1L3' 39W T5HO/ELIG | 42          |
| 1F47HSE               | 1L4' 47W T5HO/ELIG | 53          |
| 1F50HSE               | 1L4' 50W T5HO/ELIG | 58          |
| 1F54HSE               | 1L4' 54W T5HO/ELIG | 59          |
| 2F14SSE               | 2L2' 14W T5/ELIG   | 32          |
| 2F21SSE               | 2L3' 21W T5/ELIG   | 47          |
| 2F24HSE               | 2L2' 24W T5HO/ELIG | 52          |
| 2F28SSE               | 2L4' 28W T5/ELIG   | 63          |
| 2F39HSE               | 2L3' 39W T5HO/ELIG | 85          |
| 2F47HSE               | 2L4' 47W T5HO/ELIG | 103         |

| Device Code | Device Description  | Rated Watts |
|-------------|---------------------|-------------|
| 2F50HSE     | 2L4' 50W T5HO/ELIG  | 110         |
| 2F54HSE     | 2L4' 54W T5HO/ELIG  | 117         |
| 3F14SSE     | 3L2' 14W T5/ELIG    | 50          |
| 3F24HSE     | 3L4' T5HO/ELIG      | 80          |
| 3F28SSE     | 3L4' 28W T5/ELIG    | 95          |
| 3F47HSE     | 3L4' 47W T5HO/ELIG  | 157         |
| 3F50HSE     | 3L4' 50W T5HO/ELIG  | 168         |
| 3F54HSE     | 3L4' 54W T5HO/ELIG  | 177         |
| 4F14SSE     | 4L2' 14W T5/ELIG    | 68          |
| 4F28SSE     | 4L4' 28W T5/ELIG    | 126         |
| 4F47HSE     | 4L4' 47W T5HO/ELIG  | 200         |
| 4F50HSE     | 4L4' 50W T5HO/ELIG  | 215         |
| 4F54ESH     | 4L4' 54W T5HO/ELEE  | 218         |
| 4F54HSE     | 4L4' 54W T5HO/ELIG  | 234         |
| 5F47HSE     | 5L4' 47W T5HO/ELIG  | 260         |
| 5F50HSE     | 5L4' 50W T5HO/ELIG  | 278         |
| 5F54HSE     | 5L4' 54W T5HO/ELIG  | 294         |
| 6F28SSE     | 6L4' 28W T5/ELIG    | 189         |
| 6F47HSE     | 6L4' 47W T5HO/ELIG  | 303         |
| 6F50HSE     | 6L4' 50W T5HO/ELIG  | 325         |
| 6F54HSE     | 6L4' 54W T5HO/ELIG  | 351         |
| 8F54HSE     | 8L4' 54W T5HO/ELIG  | 468         |
| 10F54HSE    | 10L4' 54W T5HO/ELIG | 585         |

| Device Code                                        | Device Description             | Rated Watts |
|----------------------------------------------------|--------------------------------|-------------|
| <b><i>Two-Foot-High Efficient T8 Systems</i></b>   |                                |             |
| 1F17ESL                                            | 1L2' 17W T8EE/ELEE<br>LOW PWR  | 14          |
| 1F17ESN                                            | 1L2' 17W T8EE/ELEE             | 17          |
| 1F17ESH                                            | 1L2' 17W T8EE/ELEE<br>HIGH PWR | 20          |
| 1F28BXE                                            | 1L2' F28BX/ELIG                | 32          |
| 2F17ESL                                            | 2L2' 17W T8EE/ELEE<br>LOW PWR  | 27          |
| 2F17ESN                                            | 2L2' 17W T8EE/ELEE             | 32          |
| 2F17ESH                                            | 2L2' 17W T8EE/ELEE<br>HIGH PWR | 40          |
| 2F28BXE                                            | 2L2' F28BX/ELIG                | 63          |
| 3F17ESL                                            | 3L2' 17W T8EE/ELEE<br>LOW PWR  | 39          |
| 3F17ESN                                            | 3L2' 17W T8EE/ELEE             | 46          |
| 3F17ESH                                            | 3L2' 17W T8EE/ELEE<br>HIGH PWR | 61          |
| 3F28BXE                                            | 3L2' F28BX/ELIG                | 94          |
| <b><i>Three-Foot-High Efficient T8 Systems</i></b> |                                |             |
| 1F25ESL                                            | 1L3' 25W T8EE/ELEE<br>LOW PWR  | 21          |
| 1F25ESN                                            | 1L3' 25W T8EE/ELEE             | 24          |
| 1F25ESH                                            | 1L3' 25W T8EE/ELEE<br>HIGH PWR | 30          |
| 2F25ESL                                            | 2L3' 25W T8EE/ELEE<br>LOW PWR  | 40          |
| 2F25ESN                                            | 2L3' 25W T8EE/ELEE             | 45          |
| 2F25ESH                                            | 2L3' 25W T8EE/ELEE<br>HIGH PWR | 60          |

| Device Code                                                        | Device Description             | Rated Watts |
|--------------------------------------------------------------------|--------------------------------|-------------|
| 3F25ESL                                                            | 3L3' 25W T8EE/ELEE<br>LOW PWR  | 58          |
| 3F25ESN                                                            | 3L3' 25W T8EE/ELEE             | 67          |
| 3F25ESH                                                            | 3L3' 25W T8EE/ELEE<br>HIGH PWR | 90          |
| <b><i>Four Foot T8 High Efficient / Reduce Wattage Systems</i></b> |                                |             |
| 1F25EEH                                                            | 1L4' 25W T8EE/ELEE<br>HIGH PWR | 30          |
| 1F25EEE                                                            | 1L4' 25W T8EE/ELEE             | 22          |
| 1F25EEL                                                            | 1L4' 25W T8EE/ELEE<br>LOW PWR  | 19          |
| 2F25EEH                                                            | 2L4' 25W T8EE/ELEE<br>HIGH PWR | 57          |
| 2F25EEE                                                            | 2L4' 25W T8EE/ELEE             | 43          |
| 2F25EEL                                                            | 2L4' 25W T8EE/ELEE<br>LOW PWR  | 37          |
| 3F25EEH                                                            | 3L4' 25W T8EE/ELEE<br>HIGH PWR | 86          |
| 3F25EEE                                                            | 3L4' 25W T8EE/ELEE             | 64          |
| 3F25EEL                                                            | 3L4' 25W T8EE/ELEE<br>LOW PWR  | 57          |
| 4F25EEH                                                            | 4L4' 25W T8EE/ELEE<br>HIGH PWR | 111         |
| 4F25EEE                                                            | 4L4' 25W T8EE/ELEE             | 86          |
| 4F25EEL                                                            | 4L4' 25W T8EE/ELEE<br>LOW PWR  | 75          |
| 1F28EEH                                                            | 1L4' 28W T8EE/ELEE<br>HIGH PWR | 33          |
| 1F28EEE                                                            | 1L4' 28W T8EE/ELEE             | 24          |
| 1F28EEL                                                            | 1L4' 28W T8EE/ELEE<br>LOW PWR  | 22          |

| Device Code | Device Description             | Rated Watts |
|-------------|--------------------------------|-------------|
| 2F28EEH     | 2L4' 28WT8EE/ELEE<br>HIGH PWR  | 64          |
| 2F28EEE     | 2L4' 28W T8EE/ELEE             | 48          |
| 2F28EEL     | 2L4' 28W T8EE/ELEE<br>LOW PWR  | 42          |
| 3F28EEH     | 3L4' 28W T8EE/ELEE<br>HIGH PWR | 96          |
| 3F28EEE     | 3L4' 28W T8EE/ELEE             | 72          |
| 3F28EEL     | 3L4' 28W T8EE/ELEE<br>LOW PWR  | 63          |
| 4F28EEH     | 4L4' 28W T8EE/ELEE<br>HIGH PWR | 126         |
| 4F28EEE     | 4L4' 28W T8EE/ELEE             | 94          |
| 4F28EEL     | 4L4' 28W T8EE/ELEE<br>LOW PWR  | 83          |
| 1F30EEH     | 1L4' 30W T8EE/ELEE<br>HIGH PWR | 36          |
| 1F30EEE     | 1L4' 30W T8EE/ELEE             | 26          |
| 1F30EEL     | 1L4' 30W T8EE/ELEE<br>LOW PWR  | 24          |
| 2F30EEH     | 2L4' 30WT8EE/ELEE<br>HIGH PWR  | 69          |
| 2F30EEE     | 2L4' 30W T8EE/ELEE             | 52          |
| 2F30EEL     | 2L4' 30W T8EE/ELEE<br>LOW PWR  | 45          |
| 3F30EEH     | 3L4' 30W T8EE/ELEE<br>HIGH PWR | 103         |
| 3F30EEE     | 3L4' 30W T8EE/ELEE             | 77          |
| 3F30EEL     | 3L4' 30W T8EE/ELEE<br>LOW PWR  | 68          |
| 4F30EEH     | 4L4' 30W T8EE/ELEE<br>HIGH PWR | 133         |

| Device Code | Device Description             | Rated Watts |
|-------------|--------------------------------|-------------|
| 4F30EEE     | 4L4' 30W T8EE/ELEE             | 101         |
| 4F30EEL     | 4L4' 30W T8EE/ELEE<br>LOW PWR  | 89          |
| 1F32EEH     | 1L4' 32W T8EE/ELEE<br>HIGH PWR | 38          |
| 1F32EEE     | 1L4' 32W T8EE/ELEE             | 28          |
| 1F32EEL     | 1L4' 32W T8EE/ELEE<br>LOW PWR  | 25          |
| 2F32EEH     | 2L4' 32W T8EE/ELEE<br>HIGH PWR | 73          |
| 2F32EEE     | 2L4' 32W T8EE/ELEE             | 53          |
| 2F32EEL     | 2L4' 32W T8EE/ELEE<br>LOW PWR  | 47          |
| 3F32EEH     | 3L4' 32W T8EE/ELEE<br>HIGH PWR | 109         |
| 3F32EEE     | 3L4' 32W T8EE/ELEE             | 82          |
| 3F32EEL     | 3L4' 32W T8EE/ELEE<br>LOW PWR  | 72          |
| 4F32EEH     | 4L4' 32W T8EE/ELEE<br>HIGH PWR | 141         |
| 4F32EEE     | 4L4' 32W T8EE/ELEE             | 107         |
| 4F32EEL     | 4L4' 32W T8EE/ELEE<br>LOW PWR  | 95          |
| 5F32EEH     | 5L4' 32W T8EE/ELEE<br>HIGH PWR | 182         |
| 6F28EEE     | 6L4' 28W T8EE/ELEE             | 144         |
| 6F28EEH     | 6L4' 28W T8EE/ELEE<br>HIGH PWR | 192         |
| 6F28EEL     | 6L4' 28W T8EE/ELEE<br>LOW PWR  | 126         |
| 6F30EEE     | 6L4' 30W T8EE/ELEE             | 154         |
| 6F30EEL     | 6L4' 30W T8EE/ELEE<br>LOW PWR  | 136         |

| Device Code                             | Device Description          | Rated Watts |
|-----------------------------------------|-----------------------------|-------------|
| 6F32EEH                                 | 6L4' 32W T8EE/ELEE HIGH PWR | 218         |
| 6F32EEE                                 | 6L4' 32W T8EE/ELEE          | 168         |
| 6F32EEL                                 | 6L4' 32W T8EE/ELEE LOW PWR  | 146         |
| 7F32EEH                                 | 7L4' 32W T8EE/ELEE HIGH PWR | 250         |
| <b>Eight Foot T8 Systems</b>            |                             |             |
| 1F59SSE                                 | 1L8' T8/ELIG                | 60          |
| 1F80SSE                                 | 1L8' T8 HO/ELIG             | 85          |
| 2F59SSE                                 | 2L8' T8/ELIG                | 109         |
| 2F59SSL                                 | 2L8' T8/ELIG LOW PWR        | 100         |
| 2F80SSE                                 | 2L8' T8 HO/ELIG             | 160         |
| <b>Tandem Wired T8 High Efficient</b>   |                             |             |
| 2W32EEE                                 | 2L4' TW T8EE/ELIG           | 27          |
| 2W32EEL                                 | 2L4' TW T8EE/ELEE LOW PWR   | 24          |
| 3W32EEE                                 | 3L4' TW T8EE/ELIG           | 39          |
| 3W32EEL                                 | 3L4' TW T8EE/ELEE LOW PWR   | 34          |
| 4W32EEE                                 | 4L4' TW T8EE/ELIG           | 51          |
| 4W32EEL                                 | 4L4' TW T8EE/ELEE LOW PWR   | 45          |
| <b>Tandem-Wired Fluorescent Systems</b> |                             |             |
| 2W32SSE                                 | 2L4' TW T8/ELIG             | 30          |
| 2W32SSH                                 | 2L4' TW T8/HI-LUM           | 39          |
| 2W40SEE                                 | 2L4' TW EE/ELIG             | 30          |
| 2W40SSE                                 | 2L4' TW STD/ELIG            | 36          |
| 2W59HSE                                 | 2L8' TW T8 HO/ELIG          | 80          |

| Device Code                  | Device Description         | Rated Watts |
|------------------------------|----------------------------|-------------|
| 2W59SSE                      | 2L8' TW T8/ELIG            | 55          |
| 2W96HEE                      | 2L8' TW HO-EE/ELIG         | 85          |
| 2W96HSE                      | 2L8' TW HO-STD/ELIG        | 98          |
| 2W96SEE                      | 2L8' TW EE/ELIG            | 55          |
| 2W96SSE                      | 2L8' TW STD/ELIG           | 67          |
| 3W32SSE                      | 3L4' TW T8/ELIG            | 29          |
| 4D17SSE                      | 4L2' TW T8/ELIG            | 31          |
| 4D32EEE                      | 4L4' DTW T8EE/ELIG         | 51          |
| 4D32EEL                      | 4L4' DTW T8EE/ELEE LOW PWR | 45          |
| 4D32SSE                      | 4L4' DTW T8/ELIG           | 53          |
| 4D32SSL                      | 4L4 DTWT8/ELIG LOW POWER   | 49          |
| 4W32SSE                      | 4L4' TW T8/ELIG            | 27          |
| 4W32SSL                      | 4L4 TWT8/ELIG LOW POWER    | 25          |
| <b>LED Lighting Fixtures</b> |                            |             |
| 1L002                        | 2 WATT LED                 | 2           |
| 1L003                        | 3 WATT LED                 | 3           |
| 1L004                        | 4 WATT LED                 | 4           |
| 1L005                        | 5 WATT LED                 | 5           |
| 1L006                        | 6 WATT LED                 | 6           |
| 1L007                        | 7 WATT LED                 | 7           |
| 1L008                        | 8 WATT LED                 | 8           |
| 1L009                        | 9 WATT LED                 | 9           |
| 1L010                        | 10 WATT LED                | 10          |
| 1L011                        | 11 WATT LED                | 11          |

| Device Code | Device Description | Rated Watts |
|-------------|--------------------|-------------|
| 1L012       | 12 WATT LED        | 12          |
| 1L013       | 13 WATT LED        | 13          |
| 1L014       | 14 WATT LED        | 14          |
| 1L015       | 15 WATT LED        | 15          |
| 1L016       | 16 WATT LED        | 16          |
| 1L017       | 17 WATT LED        | 17          |
| 1L018       | 18 WATT LED        | 18          |
| 1L019       | 19 WATT LED        | 19          |
| 1L020       | 20 WATT LED        | 20          |
| 1L021       | 21 WATT LED        | 21          |
| 1L022       | 22 WATT LED        | 22          |
| 1L023       | 23 WATT LED        | 23          |
| 1L024       | 24 WATT LED        | 24          |
| 1L025       | 25 WATT LED        | 25          |
| 1L026       | 26 WATT LED        | 26          |
| 1L027       | 27 WATT LED        | 27          |
| 1L028       | 28 WATT LED        | 28          |
| 1L029       | 29 WATT LED        | 29          |
| 1L030       | 30 WATT LED        | 30          |
| 1L031       | 31 WATT LED        | 31          |
| 1L032       | 32 WATT LED        | 32          |
| 1L033       | 33 WATT LED        | 33          |
| 1L034       | 34 WATT LED        | 34          |
| 1L035       | 35 WATT LED        | 35          |
| 1L036       | 36 WATT LED        | 36          |
| 1L037       | 37 WATT LED        | 37          |

| Device Code                  | Device Description | Rated Watts |
|------------------------------|--------------------|-------------|
| 1L038                        | 38 WATT LED        | 38          |
| 1L039                        | 39 WATT LED        | 39          |
| 1L040                        | 40 WATT LED        | 40          |
| 1L041                        | 41 WATT LED        | 41          |
| 1L042                        | 42 WATT LED        | 42          |
| <b>LED Lighting Fixtures</b> |                    |             |
| 1L043                        | 43 WATT LED        | 43          |
| 1L044                        | 44 WATT LED        | 44          |
| 1L045                        | 45 WATT LED        | 45          |
| 1L046                        | 46 WATT LED        | 46          |
| 1L047                        | 47 WATT LED        | 47          |
| 1L048                        | 48 WATT LED        | 48          |
| 1L049                        | 49 WATT LED        | 49          |
| 1L050                        | 50 WATT LED        | 50          |
| 1L053                        | 53 WATT LED        | 53          |
| 1L055                        | 55 WATT LED        | 55          |
| 1L060                        | 60 WATT LED        | 60          |
| 1L063                        | 63 WATT LED        | 63          |
| 1L070                        | 70 WATT LED        | 70          |
| 1L071                        | 71 WATT LED        | 71          |
| 1L073                        | 73 WATT LED        | 73          |
| 1L075                        | 75 WATT LED        | 75          |
| 1L080                        | 90 WATT LED        | 90          |
| 1L085                        | 85 WATT LED        | 85          |
| 1L090                        | 90 WATT LED        | 90          |
| 1L095                        | 95 WATT LED        | 95          |



| Device Code | Device Description | Rated Watts |
|-------------|--------------------|-------------|
| 1L100       | 100 WATT LED       | 100         |
| 1L101       | 101 WATT LED       | 101         |
| 1L106       | 106 WATT LED       | 106         |
| 1L107       | 107 WATT LED       | 107         |
| 1L116       | 116 WATT LED       | 116         |
| 1L120       | 120 WATT LED       | 120         |
| 1L125       | 125 WATT LED       | 125         |
| 1L130       | 130 WATT LED       | 130         |
| 1L131       | 131 WATT LED       | 131         |
| 1L135       | 135 WATT LED       | 135         |
| 1L139       | 139 WATT LED       | 139         |
| 1L140       | 140 WATT LED       | 140         |
| 1L145       | 145 WATT LED       | 145         |
| 1L150       | 150 WATT LED       | 150         |
| 1L155       | 155 WATT LED       | 155         |
| 1L160       | 160 WATT LED       | 160         |
| 1L164       | 164 WATT LED       | 164         |
| 1L165       | 165 WATT LED       | 165         |
| 1L170       | 170 WATT LED       | 170         |
| 1L175       | 175 WATT LED       | 175         |
| 1L180       | 180 WATT LED       | 180         |
| 1L185       | 185 WATT LED       | 185         |
| 1L186       | 186 WATT LED       | 186         |
| 1L190       | 190 WATT LED       | 190         |
| 1L200       | 200 WATT LED       | 200         |
| 1L204       | 204 WATT LED       | 204         |

| Device Code | Device Description | Rated Watts |
|-------------|--------------------|-------------|
| 1L205       | 205 WATT LED       | 205         |
| 1L210       | 210 WATT LED       | 210         |
| 1L211       | 211 WATT LED       | 211         |
| 1L220       | 220 WATT LED       | 220         |
| 1L233       | 233 WATT LED       | 233         |
| 1L235       | 235 WATT LED       | 235         |
| 1L237       | 237 WATT LED       | 237         |
| 1L240       | 240 WATT LED       | 240         |
| 1L256       | 256 WATT LED       | 256         |
| 1L279       | 279 WATT LED       | 279         |
| 1LED015     | 15 Watt LED        | 15          |

**Table A-5: Default Effective Lighting Hours by Building Type<sup>5</sup>**

| <b>Building Type</b>     | <b>Annual Operating Hours</b> |
|--------------------------|-------------------------------|
| College & University     | 4,132                         |
| Grocery/Food Sales       | 5,920                         |
| Hospital                 | 5,601                         |
| Industrial/Manufacturing | 5,229                         |
| K-12 School              | 2,902                         |
| Lodging                  | 4,194                         |
| Medical Office           | 3,673                         |
| Office Building          | 4,171                         |
| Other                    | 4,141                         |
| Parking Garage           | 8,263                         |
| Restaurant/Food Service  | 4,891                         |
| Retail                   | 4,957                         |

<sup>5</sup> DNV GL (2018). *Lighting Hours of Use Study, Table 3-1*. Prepared for MA Program Administrators and EEAC.

**Table A-6: Cooling and Heating Equivalent Full Load Hours**

| <b>Building (or Space) Type</b> | <b>Annual Cooling Hours (Hours<sub>cool</sub>)</b> | <b>Cooling Full Load Hours (EFLH<sub>cool</sub>)</b> | <b>Heating Full Load Hours (EFLH<sub>heat</sub>)</b> |
|---------------------------------|----------------------------------------------------|------------------------------------------------------|------------------------------------------------------|
| Average – CLC                   | 3,027                                              | 1,172                                                | 530                                                  |
| Average – NSTAR                 | 3,027                                              | 1,172                                                | N/A                                                  |
| Average – National Grid         | 2,539                                              | 935                                                  | 984                                                  |
| Average – Unitil                | 1,896                                              | 755                                                  | 1,329                                                |
| Average – WMECO                 | 1,896                                              | 755                                                  | 1,329                                                |
| Site Specific - NSTAR           | 800, 1000-6000 at 1000-hour increments             | 800, 1000-6000 at 1000-hour increments               | N/A                                                  |

- Average Cooling EFLHs from the 2010 NEEP HVAC Loadshape study.<sup>6</sup> Regional EFLHs from the NEEP study are determined for each PA by applying weights based on ISO-NE load zones.
- Average Cooling Hours derived from the 2010 NEEP HVAC Loadshape study data.<sup>7</sup>
- Average Heating EFLHs derived from 2010 NEEP HVAC Loadshape study<sup>8</sup> and the Connecticut Program Savings Document for 2011 Program Year.<sup>9</sup>

<sup>6</sup> KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

<sup>7</sup> DNV GL (2014). *Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study*. Prepared for National Grid and Northeast Utilities. August 20, 2014.

<sup>8</sup> Ibid.

<sup>9</sup> United Illuminating Company, Connecticut Light & Power Company (2010). *UI and CL&P Program Savings Documentation for 2011 Program Year*.

## Appendix B: Non-Energy Impacts

**Table B-1: Residential and Income Eligible Non-Energy Impacts (NEIs)**

| Sector      | NEI Description         | NEI Category                  | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-------------|-------------------------|-------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential | Residential Bulb        | Lighting Quality and Lifetime |                 | \$3.00            |                |                  |                  |                    |
| Residential | Residential Fixture     | Lighting Quality and Lifetime |                 | \$3.50            |                |                  |                  |                    |
| Residential | RNC Heating             |                               | Varies by PA    |                   |                |                  |                  |                    |
| Residential | RNC Heating             | Thermal Comfort               | \$91.50         |                   |                |                  |                  |                    |
| Residential | RNC Heating             | Noise Reduction               | \$47.53         |                   |                |                  |                  |                    |
| Residential | RNC Heating             | Health Benefits               | \$3.30          |                   |                |                  |                  |                    |
| Residential | RNC Heating, R&A        |                               | Varies by PA    |                   |                |                  |                  |                    |
| Residential | RNC Heating, R&A        | Thermal Comfort               | \$91.50         |                   |                |                  |                  |                    |
| Residential | RNC Heating, R&A        | Noise Reduction               | \$47.53         |                   |                |                  |                  |                    |
| Residential | RNC Heating, R&A        | Health Benefits               | \$3.30          |                   |                |                  |                  |                    |
| Residential | Residential Air Sealing |                               | \$19.28         |                   |                |                  |                  |                    |
| Residential | Residential Air Sealing | Thermal Comfort               | \$10.13         |                   |                |                  |                  |                    |
| Residential | Residential Air Sealing | Noise Reduction               | \$4.88          |                   |                |                  |                  |                    |
| Residential | Residential Air Sealing | Home Durability               | \$3.95          |                   |                |                  |                  |                    |
| Residential | Residential Air Sealing | Health Benefits               | \$0.32          |                   |                |                  |                  |                    |
| Residential | Residential Insulation  |                               | \$47.31         |                   |                |                  |                  |                    |

| Sector      | NEI Description          | NEI Category            | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-------------|--------------------------|-------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential | Residential Insulation   | Thermal Comfort         | \$25.15         |                   |                |                  |                  |                    |
| Residential | Residential Insulation   | Noise Reduction         | \$11.54         |                   |                |                  |                  |                    |
| Residential | Residential Insulation   | Home Durability         | \$9.82          |                   |                |                  |                  |                    |
| Residential | Residential Insulation   | Health Benefits         | \$0.80          |                   |                |                  |                  |                    |
| Residential | Residential Duct Sealing |                         | \$0.23          |                   |                |                  |                  |                    |
| Residential | Residential Duct Sealing | Thermal Comfort         | \$0.16          |                   |                |                  |                  |                    |
| Residential | Residential Duct Sealing | Home Durability         | \$0.06          |                   |                |                  |                  |                    |
| Residential | Residential Duct Sealing | Health Benefits         | \$0.01          |                   |                |                  |                  |                    |
| Residential | Residential Showerhead   | Property Value Increase |                 | \$0.03            |                |                  |                  |                    |
| Residential | Residential Thermostats  |                         | Varies by PA    |                   |                |                  |                  |                    |
| Residential | Residential Thermostats  | Thermal Comfort         | \$3.99          |                   |                |                  |                  |                    |
| Residential | Residential Thermostats  | Home Durability         | \$1.33          |                   |                |                  |                  |                    |
| Residential | Residential Thermostats  | Health Benefits         | \$0.13          |                   |                |                  |                  |                    |
| Residential | Residential Refrigerator | Property Value Increase |                 | \$1.44            |                |                  |                  |                    |
| Residential | Residential Furnace      |                         | \$99.74         |                   |                |                  |                  |                    |
| Residential | Residential Furnace      | Thermal Comfort         | \$36.35         |                   |                |                  |                  |                    |
| Residential | Residential Furnace      | Home Durability         | \$11.53         |                   |                |                  |                  |                    |
| Residential | Residential Furnace      | Equipment Maintenance   | \$50.69         |                   |                |                  |                  |                    |
| Residential | Residential Furnace      | Health Benefits         | \$1.17          |                   |                |                  |                  |                    |

| Sector      | NEI Description                      | NEI Category          | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-------------|--------------------------------------|-----------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential | Residential Furnace, Gas             |                       | \$30.84         |                   |                |                  |                  |                    |
| Residential | Residential Furnace, Gas             | Thermal Comfort       | \$35.01         |                   |                |                  |                  |                    |
| Residential | Residential Furnace, Gas             | Home Durability       | \$10.88         |                   |                |                  |                  |                    |
| Residential | Residential Furnace, Gas             | Equipment Maintenance | \$45.06         |                   |                |                  |                  |                    |
| Residential | Residential Furnace, Gas             | Health Benefits       | \$1.12          |                   |                |                  |                  |                    |
| Residential | Residential Boiler                   |                       | \$96.40         |                   |                |                  |                  |                    |
| Residential | Residential Boiler                   | Thermal Comfort       | \$35.77         |                   |                |                  |                  |                    |
| Residential | Residential Boiler                   | Home Durability       | \$11.25         |                   |                |                  |                  |                    |
| Residential | Residential Boiler                   | Equipment Maintenance | \$48.23         |                   |                |                  |                  |                    |
| Residential | Residential Boiler                   | Health Benefits       | \$1.15          |                   |                |                  |                  |                    |
| Residential | Residential Boiler, Gas              |                       | \$30.84         |                   |                |                  |                  |                    |
| Residential | Residential Boiler, Gas              | Thermal Comfort       | \$33.07         |                   |                |                  |                  |                    |
| Residential | Residential Boiler, Gas              | Home Durability       | \$9.95          |                   |                |                  |                  |                    |
| Residential | Residential Boiler, Gas              | Equipment Maintenance | \$36.86         |                   |                |                  |                  |                    |
| Residential | Residential Boiler, Gas              | Health Benefits       | \$1.06          |                   |                |                  |                  |                    |
| Residential | Residential Water Heater Replacement | Home Durability       | \$0.70          |                   |                |                  |                  |                    |
| Residential | Residential DHW - Tankless           | Home Durability       | \$1.23          |                   |                |                  |                  |                    |
| Residential | Residential DHW - Stand Alone        | Home Durability       | \$1.30          |                   |                |                  |                  |                    |
| Residential | Residential Combo Condensing Furnace |                       | \$30.84         |                   |                |                  |                  |                    |

| <b>Sector</b> | <b>NEI Description</b>               | <b>NEI Category</b>        | <b>Annual per Unit</b> | <b>One time per Unit</b> | <b>Annual per kWh</b> | <b>One time per kWh</b> | <b>Annual per Therm</b> | <b>One time per Therm</b> |
|---------------|--------------------------------------|----------------------------|------------------------|--------------------------|-----------------------|-------------------------|-------------------------|---------------------------|
| Residential   | Residential Combo Condensing Furnace | Thermal Comfort            | \$24.32                |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Condensing Furnace | Home Durability            | \$5.75                 |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Condensing Furnace | Health Benefits            | \$0.78                 |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Boiler             |                            | \$75.52                |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Boiler             | Thermal Comfort            | \$32.12                |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Boiler             | Home Durability            | \$9.50                 |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Boiler             | Home Durability            | \$32.87                |                          |                       |                         |                         |                           |
| Residential   | Residential Combo Boiler             | Health Benefits            | \$1.03                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           |                            | \$19.35                |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           | Thermal Comfort            | \$10.13                |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           | Noise Reduction            | \$4.88                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           | Health Benefits            | \$0.32                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           | Rental Units Marketability | \$0.07                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           | Reduced Tenant Complaints  | \$1.37                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Air Sealing           | Property Durability        | \$2.58                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Insulation            |                            | \$47.31                |                          |                       |                         |                         |                           |
| Residential   | Residential MF Insulation            | Thermal Comfort            | \$25.15                |                          |                       |                         |                         |                           |

| <b>Sector</b> | <b>NEI Description</b>    | <b>NEI Category</b>                                  | <b>Annual per Unit</b> | <b>One time per Unit</b> | <b>Annual per kWh</b> | <b>One time per kWh</b> | <b>Annual per Therm</b> | <b>One time per Therm</b> |
|---------------|---------------------------|------------------------------------------------------|------------------------|--------------------------|-----------------------|-------------------------|-------------------------|---------------------------|
| Residential   | Residential MF Insulation | Noise Reduction                                      | \$11.54                |                          |                       |                         |                         |                           |
| Residential   | Residential MF Insulation | Home Durability                                      | \$9.82                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Insulation | Health Benefits                                      | \$0.80                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Showerhead |                                                      | \$0.58                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Showerhead | Rental Units Marketability                           | \$0.01                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Showerhead | Reduced Tenant Complaints                            | \$0.20                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Showerhead | Property Durability                                  | \$0.37                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Aerator    |                                                      | \$0.58                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Aerator    | Rental Units Marketability                           | \$0.01                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Aerator    | Reduced Tenant Complaints                            | \$0.20                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Aerator    | Property Durability                                  | \$0.37                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Thermostat |                                                      | Varies by PA           |                          |                       |                         |                         |                           |
| Residential   | Residential MF Thermostat | Thermal Comfort                                      | \$3.99                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Thermostat | Health Benefits                                      | \$0.13                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Thermostat | Rental Unit Marketability                            | \$0.11                 |                          |                       |                         |                         |                           |
| Residential   | Residential MF Thermostat | Equipment Maintenance Reliability Due to Thermostats | \$3.91                 |                          |                       |                         |                         |                           |



| Sector      | NEI Description                     | NEI Category               | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-------------|-------------------------------------|----------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential | Residential MF Thermostat           | Property Durability        | \$4.05          |                   |                |                  |                  |                    |
| Residential | Residential MF Thermostat           | Reduced Tenant Complaints  | \$2.16          |                   |                |                  |                  |                    |
| Residential | Residential MF Refrigerator         |                            | \$20.10         |                   |                |                  |                  |                    |
| Residential | Residential MF Refrigerator         | Rental Units Marketability | \$0.34          |                   |                |                  |                  |                    |
| Residential | Residential MF Refrigerator         | Reduced Tenant Complaints  | \$12.90         |                   |                |                  |                  |                    |
| Residential | Residential MF Refrigerator         | Property Durability        | \$6.86          |                   |                |                  |                  |                    |
| Residential | Residential MF Common-Area Lighting | O&M                        | \$26.00         |                   | \$0.03         |                  |                  |                    |
| Residential | Residential MF Heat Pump            |                            | \$5.70          |                   |                |                  |                  |                    |
| Residential | Residential MF Heat Pump            | Noise Reduction            | \$2.50          |                   |                |                  |                  |                    |
| Residential | Residential MF Heat Pump            | Home Durability            | \$1.17          |                   |                |                  |                  |                    |
| Residential | Residential MF Heat Pump            | Thermal Comfort            | \$1.96          |                   |                |                  |                  |                    |
| Residential | Residential MF Heat Pump            | Health Benefits            | \$0.07          |                   |                |                  |                  |                    |
| Residential | Residential MF DMSHP                |                            | \$5.98          |                   |                |                  |                  |                    |
| Residential | Residential MF DMSHP                | Noise Reduction            | \$1.41          |                   |                |                  |                  |                    |
| Residential | Residential MF DMSHP                | Home Durability            | \$1.96          |                   |                |                  |                  |                    |
| Residential | Residential MF DMSHP                | Thermal Comfort            | \$2.53          |                   |                |                  |                  |                    |
| Residential | Residential MF DMSHP                | Health Benefits            | \$0.08          |                   |                |                  |                  |                    |

| Sector      | NEI Description                                  | NEI Category          | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-------------|--------------------------------------------------|-----------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential | Residential Retail Thermostats                   |                       | Varies by PA    |                   |                |                  |                  |                    |
| Residential | Residential Retail Thermostats                   | Thermal Comfort       | \$3.99          |                   |                |                  |                  |                    |
| Residential | Residential Retail Thermostats                   | Home Durability       | \$1.33          |                   |                |                  |                  |                    |
| Residential | Residential Retail Thermostats                   | Health Benefits       | \$0.13          |                   |                |                  |                  |                    |
| Residential | Residential Retail Air Conditioner               |                       | \$8.98          |                   |                |                  |                  |                    |
| Residential | Residential Retail Air Conditioner               | Thermal Comfort       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Air Conditioner               | Noise Reduction       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Air Conditioner               | Home Durability       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Air Conditioner               | Equipment Maintenance |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Air Conditioner               | Health Benefits       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Heat Pump                     |                       | \$8.11          |                   |                |                  |                  |                    |
| Residential | Residential Retail Heat Pump                     | Thermal Comfort       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Heat Pump                     | Home Durability       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Heat Pump                     | Equipment Maintenance |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Heat Pump                     | Health Benefits       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Ductless Mini Split Heat Pump |                       | \$4.21          |                   |                |                  |                  |                    |
| Residential | Residential Retail Ductless Mini Split Heat Pump | Thermal Comfort       |                 |                   |                |                  |                  |                    |

| Sector      | NEI Description                                  | NEI Category          | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-------------|--------------------------------------------------|-----------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential | Residential Retail Ductless Mini Split Heat Pump | Home Durability       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Ductless Mini Split Heat Pump | Equipment Maintenance |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Ductless Mini Split Heat Pump | Health Benefits       |                 |                   |                |                  |                  |                    |
| Residential | Residential Retail Duct Sealing                  |                       | \$0.23          |                   |                |                  |                  |                    |
| Residential | Residential Retail Down size 1/2 ton             |                       | \$0.64          |                   |                |                  |                  |                    |
| Residential | Residential Retail Down size 1/2 ton             | Thermal Comfort       | \$0.19          |                   |                |                  |                  |                    |
| Residential | Residential Retail Down size 1/2 ton             | Home Durability       | \$0.07          |                   |                |                  |                  |                    |
| Residential | Residential Retail Down size 1/2 ton             | Equipment Maintenance | \$0.37          |                   |                |                  |                  |                    |
| Residential | Residential Retail Down size 1/2 ton             | Health Benefits       | \$0.01          |                   |                |                  |                  |                    |
| Residential | Residential Retail Digital Check up/tune up      |                       | \$1.53          |                   |                |                  |                  |                    |
| Residential | Residential Retail Digital Check up/tune up      | Thermal Comfort       | \$0.47          |                   |                |                  |                  |                    |
| Residential | Residential Retail Digital Check up/tune up      | Home Durability       | \$0.18          |                   |                |                  |                  |                    |
| Residential | Residential Retail Digital Check up/tune up      | Equipment Maintenance | \$0.87          |                   |                |                  |                  |                    |
| Residential | Residential Retail Digital Check up/tune up      | Health Benefits       | \$0.01          |                   |                |                  |                  |                    |
| Residential | Residential Retail QIV                           |                       | \$1.53          |                   |                |                  |                  |                    |

| <b>Sector</b> | <b>NEI Description</b>                       | <b>NEI Category</b>     | <b>Annual per Unit</b> | <b>One time per Unit</b> | <b>Annual per kWh</b> | <b>One time per kWh</b> | <b>Annual per Therm</b> | <b>One time per Therm</b> |
|---------------|----------------------------------------------|-------------------------|------------------------|--------------------------|-----------------------|-------------------------|-------------------------|---------------------------|
| Residential   | Residential Retail QIV                       | Thermal Comfort         | \$0.47                 |                          |                       |                         |                         |                           |
| Residential   | Residential Retail QIV                       | Home Durability         | \$0.18                 |                          |                       |                         |                         |                           |
| Residential   | Residential Retail QIV                       | Equipment Maintenance   | \$0.87                 |                          |                       |                         |                         |                           |
| Residential   | Residential Retail QIV                       | Health Benefits         | \$0.01                 |                          |                       |                         |                         |                           |
| Residential   | Residential - Windows                        | Property Value Increase | \$6.72                 |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income Boiler/Furnace |                         | \$170.01               |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income Boiler/Furnace | Thermal Comfort         | \$48.63                |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income Boiler/Furnace | Home Durability         | \$17.42                |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income Boiler/Furnace | Equipment Maintenance   | \$102.40               |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income Boiler/Furnace | Health Benefits         | \$1.56                 |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income CAC/HP         |                         | \$15.96                |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income CAC/HP         | Thermal Comfort         | \$3.92                 |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income CAC/HP         | Home Durability         | \$1.54                 |                          |                       |                         |                         |                           |
| Residential   | Residential - Moderate Income CAC/HP         | Equipment Maintenance   | \$7.54                 |                          |                       |                         |                         |                           |

| Sector          | NEI Description                      | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|--------------------------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Residential     | Residential - Moderate Income CAC/HP | Health Benefits                | \$0.13          |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income CAC/HP | Noise Reduction                | \$2.83          |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income DMSHP  |                                | \$18.03         |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income DMSHP  | Thermal Comfort                | \$5.05          |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income DMSHP  | Home Durability                | \$1.98          |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income DMSHP  | Equipment Maintenance          | \$9.42          |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income DMSHP  | Health Benefits                | \$0.16          |                   |                |                  |                  |                    |
| Residential     | Residential - Moderate Income DMSHP  | Noise Reduction                | \$1.42          |                   |                |                  |                  |                    |
| Income Eligible | IE Rate-Discount Only                |                                | \$0.00          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE Rate-Discount Only                | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE Rate-Discount Only                | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Participant                    |                                | \$10.37         | \$56.00           | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Participant                    | Arrearages                     | \$2.61          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Participant                    | Bad Debt Write-offs            | \$3.74          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Participant                    | Terminations and Reconnections | \$0.43          |                   |                |                  |                  |                    |

| Sector          | NEI Description      | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|----------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE SF Participant    | Customer Calls and Collections | \$0.58          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Participant    | Notices                        | \$0.34          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Participant    | Improved Safety                | \$2.67          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Participant    | Lighting Quality and Lifetime  |                 | \$56.00           |                |                  |                  |                    |
| Income Eligible | IE SF Participant    | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Participant    | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE Participant, Gas  |                                | \$7.70          | \$0.00            | \$0.00         | \$0.00           | \$0.00           | \$0.00             |
| Income Eligible | IE Participant, Gas  | Arrearages                     | \$2.61          |                   |                |                  |                  |                    |
| Income Eligible | IE Participant, Gas  | Bad-Debt Write-off             | \$3.74          |                   |                |                  |                  |                    |
| Income Eligible | IE Participant, Gas  | Terminations & Reconnections   | \$0.43          |                   |                |                  |                  |                    |
| Income Eligible | IE Participant, Gas  | Customer Calls & Collections   | \$0.58          |                   |                |                  |                  |                    |
| Income Eligible | IE Participant, Gas  | Notices                        | \$0.34          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Weatherization |                                | \$558.21        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Weatherization | Thermal Comfort                | \$66.02         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Weatherization | Noise Reduction                | \$29.95         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Weatherization | Home Durability                | \$19.37         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Weatherization | Health Benefits                | \$423.23        |                   |                |                  |                  |                    |
| Income Eligible | IE SF Weatherization | Improved Safety                | \$19.64         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Weatherization | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Weatherization | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |

| Sector          | NEI Description               | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|-------------------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE SF Air Sealing             |                                | \$295.21        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Air Sealing             | Thermal Comfort                | \$35.89         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Air Sealing             | Noise Reduction                | \$16.39         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Air Sealing             | Home Durability                | \$10.61         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Air Sealing             | Health Benefits                | \$230.08        |                   |                |                  |                  |                    |
| Income Eligible | IE SF Air Sealing             | Improved Safety                | \$2.24          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Air Sealing             | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Air Sealing             | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Insulation              |                                | \$263.00        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Insulation              | Thermal Comfort                | \$30.13         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Insulation              | Noise Reduction                | \$13.56         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Insulation              | Home Durability                | \$8.76          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Insulation              | Health Benefits                | \$193.15        |                   |                |                  |                  |                    |
| Income Eligible | IE SF Insulation              | Improved Safety                | \$17.40         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Insulation              | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Insulation              | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Heating System Retrofit |                                | \$310.82        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Heating System Retrofit | Safety Related Emergency Calls | \$8.43          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heating System Retrofit | Thermal Comfort                | \$33.24         |                   |                |                  |                  |                    |

| Sector          | NEI Description               | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|-------------------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE SF Heating System Retrofit | Equipment Maintenance          | \$9.72          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heating System Retrofit | Home Durability                | \$27.43         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heating System Retrofit | Health Benefits                | \$213.13        |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heating System Retrofit | Improved Safety                | \$18.87         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heating System Retrofit | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Heating System Retrofit | Price Hedging                  | \$0.00          |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Heat Pump               |                                | \$310.82        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Heat Pump               | Home Durability                | \$9.72          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heat Pump               | Thermal Comfort                | \$33.24         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heat Pump               | Health Benefits                | \$213.13        |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heat Pump               | Equipment Maintenance          | \$27.43         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heat Pump               | Improved Safety                | \$18.87         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heat Pump               | Safety Related Emergency Calls | \$8.43          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Heat Pump               | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Heat Pump               | Price Hedging                  | \$0.00          |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF HP Water Heater         |                                | \$4.64          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF HP Water Heater         | Home Durability                | \$0.20          |                   |                |                  |                  |                    |
| Income Eligible | IE SF HP Water Heater         | Improved Safety                | \$4.44          |                   |                |                  |                  |                    |



| Sector          | NEI Description           | NEI Category            | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|---------------------------|-------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE SF HP Water Heater     | Rate Discounts          |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF HP Water Heater     | Price Hedging           |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Duct Sealing        |                         | \$6.21          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Duct Sealing        | Thermal Comfort         | \$0.81          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Duct Sealing        | Home Durability         | \$0.23          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Duct Sealing        | Health Benefits         | \$5.17          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Duct Sealing        | Rate Discounts          |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Duct Sealing        | Price Hedging           |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Pipe Wrap           |                         | \$48.94         | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Pipe Wrap           | Thermal Comfort         | \$6.60          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Pipe Wrap           | Health Benefits         | \$42.34         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Pipe Wrap           | Rate Discounts          |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Pipe Wrap           | Price Hedging           |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Showerhead          |                         | \$0.00          | \$1.72            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Showerhead          | Property Value Increase |                 | \$1.72            |                |                  |                  |                    |
| Income Eligible | IE SF Showerhead          | Rate Discounts          |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Showerhead          | Price Hedging           |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Replacement Freezer |                         | \$1.40          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Replacement Freezer | Improved Safety         | \$1.40          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Replacement Freezer | Property Value Increase |                 | \$26.61           |                |                  |                  |                    |

| Sector          | NEI Description             | NEI Category                       | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|-----------------------------|------------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE SF Replacement Freezer   | Rate Discounts                     |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Replacement Freezer   | Price Hedging                      |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Refrigerator          |                                    | \$1.40          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Refrigerator          | Improved Safety                    | \$1.40          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Refrigerator          | Property Value Increase            |                 | \$26.61           |                |                  |                  |                    |
| Income Eligible | IE SF Refrigerator          | Rate Discounts                     |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Refrigerator          | Price Hedging                      |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Thermostat            |                                    | Varies by PA    | Varies by PA      | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Thermostat            | Thermal Comfort                    | \$5.78          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Thermostat            | Home Durability                    | \$1.68          |                   |                |                  |                  |                    |
| Income Eligible | IE SF Thermostat            | Health Benefits                    | \$37.07         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Thermostat            | Rate Discounts                     |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Thermostat            | Price Hedging                      |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF Window AC Replacement |                                    | \$49.50         | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE SF Window AC Replacement | Window Air Conditioner Replacement | \$49.50         |                   |                |                  |                  |                    |
| Income Eligible | IE SF Window AC Replacement | Rate Discounts                     |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF Window AC Replacement | Price Hedging                      |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Participant           |                                    | \$7.70          | \$56.00           | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |

| Sector          | NEI Description       | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|-----------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Participant NEI | Arrearages                     | \$2.61          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Participant NEI | Bad Debt Write-offs            | \$3.74          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Participant NEI | Terminations and Reconnections | \$0.43          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Participant NEI | Customer Calls and Collections | \$0.58          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Participant NEI | Notices                        | \$0.34          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Participant NEI | Lighting Quality and Lifetime  |                 | \$56.00           |                |                  |                  |                    |
| Income Eligible | IE MF Participant NEI | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Participant NEI | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Weatherization  |                                | \$771.73        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Weatherization  | Thermal Comfort                | \$684.48        |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Health Benefits                | \$23.52         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Home Productivity              | \$23.52         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Improved Safety                | \$6.24          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Noise Reduction                | \$29.95         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Property Durability            | \$2.58          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Rental Units Marketability     | \$0.07          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Weatherization  | Reduced Tenant Complaints      | \$1.37          |                   |                |                  |                  |                    |

| Sector          | NEI Description      | NEI Category               | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|----------------------|----------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Weatherization | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Weatherization | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Air Sealing    |                            | \$389.29        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Air Sealing    | Thermal Comfort            | \$342.24        |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Health Benefits            | \$11.76         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Home Productivity          | \$11.76         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Improved Safety            | \$3.12          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Noise Reduction            | \$16.39         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Property Durability        | \$2.58          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Rental Units Marketability | \$0.07          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Reduced Tenant Complaints  | \$1.37          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Air Sealing    | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Air Sealing    | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Insulation     |                            | \$391.20        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Insulation     | Thermal Comfort            | \$342.24        |                   |                |                  |                  |                    |
| Income Eligible | IE MF Insulation     | Health Benefits            | \$11.76         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Insulation     | Home Productivity          | \$11.76         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Insulation     | Improved Safety            | \$3.12          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Insulation     | Noise Reduction            | \$13.56         |                   |                |                  |                  |                    |

| Sector          | NEI Description                    | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|------------------------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Insulation                   | Home Durability                | \$8.76          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Insulation                   | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Insulation                   | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Heating System Retrofit      |                                | \$836.39        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Heating System Retrofit      | Thermal Comfort                | \$741.52        |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit      | Health Benefits                | \$25.48         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit      | Home Productivity              | \$25.48         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit      | Improved Safety                | \$6.76          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit      | Equipment Maintenance          | \$9.72          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit      | Home Durability                | \$27.43         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit      | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Heating System Retrofit      | Price Hedging                  | \$0.00          |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Heating System Retrofit, Gas |                                | \$118.10        | \$0.00            | Varies by PA   | \$0.00           | Varies by PA     |                    |
| Income Eligible | IE MF Heating System Retrofit, Gas | Safety Related Emergency Calls | \$8.43          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit, Gas | Thermal Comfort                | \$38.92         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit, Gas | Property Durability            | \$9.72          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit, Gas | Equipment Maintenance          | \$27.43         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit, Gas | Health Benefits                | \$31.00         |                   |                |                  |                  |                    |

| Sector          | NEI Description                   | NEI Category                   | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|-----------------------------------|--------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Heating System Retrofit,Gas | Improved Safety                | \$2.60          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heating System Retrofit,Gas | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Heating System Retrofit,Gas | Price Hedging                  |                 |                   |                | \$0.00           |                  |                    |
| Income Eligible | IE MF Heat Pump                   |                                | \$123.91        | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Heat Pump                   | Home Durability                | \$9.72          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heat Pump                   | Thermal Comfort                | \$28.01         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heat Pump                   | Health Benefits                | \$5.27          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heat Pump                   | Equipment Maintenance          | \$27.43         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heat Pump                   | Improved Safety                | \$45.05         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heat Pump                   | Safety Related Emergency Calls | \$8.43          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Heat Pump                   | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Heat Pump                   | Price Hedging                  | \$0.00          |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Duct Sealing                |                                | \$1.04          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Duct Sealing                | Thermal Comfort                | \$0.68          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Duct Sealing                | Home Durability                | \$0.23          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Duct Sealing                | Health Benefits                | \$0.13          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Duct Sealing                | Rate Discounts                 |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Duct Sealing                | Price Hedging                  |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Pipe Wrap                   |                                | \$6.61          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |

| Sector          | NEI Description    | NEI Category               | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|--------------------|----------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Pipe Wrap    | Thermal Comfort            | \$5.56          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Pipe Wrap    | Health Benefits            | \$1.05          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Pipe Wrap    | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Pipe Wrap    | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Water Heater |                            | \$1.19          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Water Heater | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Water Heater | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Water Heater | Improved Safety            | \$0.61          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Water Heater | Rental Units Marketability | \$0.01          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Water Heater | Property Durability        | \$0.37          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Water Heater | Reduced Tenant Complaints  | \$0.20          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Showerhead   |                            | \$0.58          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Showerhead   | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Showerhead   | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Showerhead   | Rental Units Marketability | \$0.01          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Showerhead   | Home Durability            | \$0.37          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Showerhead   | Reduced Tenant Complaints  | \$0.20          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Aerator      |                            | \$0.58          | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Aerator      | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |

| Sector          | NEI Description            | NEI Category                                         | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|----------------------------|------------------------------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Aerator              | Price Hedging                                        |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Aerator              | Rental Units Marketability                           | \$0.01          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Aerator              | Home Durability                                      | \$0.37          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Aerator              | Reduced Tenant Complaints                            | \$0.20          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           |                                                      | Varies by PA    | Varies by PA      | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Thermostat           | Thermal Comfort                                      | \$4.87          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           | Health Benefits                                      | \$0.92          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           | Rental Unit Marketability                            | \$0.11          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           | Equipment Maintenance Reliability Due to Thermostats | \$3.91          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           | Property Durability                                  | \$4.05          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           | Reduced Tenant Complaints                            | \$2.16          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Thermostat           | Rate Discounts                                       |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Thermostat           | Price Hedging                                        |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Common Area Lighting |                                                      | \$29.64         | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Common Area Lighting | Rate Discounts                                       |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Common Area Lighting | Price Hedging                                        |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Common Area Lighting | Lighting Quality and Lifetime                        | \$29.64         |                   |                |                  |                  |                    |



| Sector          | NEI Description                 | NEI Category               | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|---------------------------------|----------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE MF Freezer                   |                            | \$20.29         | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Freezer                   | Rental Units Marketability | \$0.34          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Freezer                   | Property Durability        | \$12.90         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Freezer                   | Reduced Tenant Complaints  | \$6.86          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Freezer                   | Improved Safety            | \$0.19          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Freezer                   | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Freezer                   | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE MF Refrigerator              |                            | \$20.29         | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Refrigerator              | Rental Units Marketability | \$0.34          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Refrigerator              | Property Durability        | \$12.90         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Refrigerator              | Reduced Tenant Complaints  | \$6.86          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Refrigerator              | Improved Safety            | \$0.19          |                   |                |                  |                  |                    |
| Income Eligible | IE MF Refrigerator              | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Refrigerator              | Price Hedging              |                 |                   |                | \$0.01           |                  | \$0.00             |
| Income Eligible | IE SF DHW - Condensing/Indirect |                            | \$0.70          | \$0.00            | Varies by PA   | \$0.00           | Varies by PA     |                    |
| Income Eligible | IE SF DHW - Condensing/Indirect | Home Durability            | \$0.70          |                   |                |                  |                  |                    |
| Income Eligible | IE SF DHW - Condensing/Indirect | Rate Discounts             |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE SF DHW - Condensing/Indirect | Price Hedging              |                 |                   |                | \$0.00           |                  |                    |

| Sector          | NEI Description             | NEI Category                       | Annual per Unit | One time per Unit | Annual per kWh | One time per kWh | Annual per Therm | One time per Therm |
|-----------------|-----------------------------|------------------------------------|-----------------|-------------------|----------------|------------------|------------------|--------------------|
| Income Eligible | IE DHW - Stand Alone        |                                    | \$1.30          | \$0.00            | Varies by PA   | \$0.00           | Varies by PA     |                    |
| Income Eligible | IE DHW - Stand Alone        | Home Durability                    | \$1.30          |                   |                |                  |                  |                    |
| Income Eligible | IE DHW - Stand Alone        | Rate Discounts                     |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE DHW - Stand Alone        | Price Hedging                      |                 |                   |                | \$0.00           |                  |                    |
| Income Eligible | IE MF Window AC Replacement |                                    | \$49.50         | \$0.00            | Varies by PA   | \$0.01           | Varies by PA     | \$0.00             |
| Income Eligible | IE MF Window AC Replacement | Window Air Conditioner Replacement | \$49.50         |                   |                |                  |                  |                    |
| Income Eligible | IE MF Window AC Replacement | Rate Discounts                     |                 |                   | Varies by PA   |                  | Varies by PA     |                    |
| Income Eligible | IE MF Window AC Replacement | Price Hedging                      |                 |                   |                | \$0.01           |                  | \$0.00             |

**Sources:**

Residential and Income Eligible NEIs are based on the following reports:

NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation*. Prepared for the Massachusetts Program Administrators.

NMR, ThreeCubed (2021). *Low-Income Multifamily Health- and Safety-Related NEIs Study*.

NMR, ThreeCubed (2021). *RNC NEI Quick Hit Assessment*

ThreeCubed, NMR (2016). *Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study*

NMR Group, Inc. (2018). *Market-Rate Multifamily NEI – Phase I Final Memo*.

Source for lighting quality and price hedging NEIs for Low Income is EMC (2012). *Additional Non-Energy Impacts for Low Income Programs*.

Residential HVAC NEIs are based on NMR Group, Inc. (2011) but adjusted based on NMR Group, Inc.

(2013) *Massachusetts Residential Non-Energy Impacts (NEIs): Deemed NEI Values Addressing Differences in NEIs for Heating, Cooling, and Water Heating Equipment that is Early Replacement Compared to Replace on Failure*.

**Table B-2: Electric C&I Non-Energy Impacts**

| Sector                  | NEI Description                                            | NEI Category   | Annual per kWh |
|-------------------------|------------------------------------------------------------|----------------|----------------|
| Commercial & Industrial | C&I - Custom Hot Water & Other                             | O&M, H&S, etc. | \$0.07         |
| Commercial & Industrial | C&I - Custom Lighting                                      | O&M, H&S, etc. | \$0.10         |
| Commercial & Industrial | C&I - Foodservice                                          | O&M, H&S, etc. | \$0.01         |
| Commercial & Industrial | C&I - Prescriptive Lighting                                | O&M, H&S, etc. | \$0.05         |
| Commercial & Industrial | C&I - Prescriptive Motors (including compressed air)       | O&M, H&S, etc. | \$0.00         |
| Commercial & Industrial | C&I - Prescriptive Refrigeration                           | O&M, H&S, etc. | \$0.00         |
| Commercial & Industrial | C&I Comprehensive Design                                   | O&M, H&S, etc. | \$0.16         |
| Commercial & Industrial | C&I Comprehensive Retrofit                                 | O&M, H&S, etc. | \$0.17         |
| Commercial & Industrial | C&I New CHP                                                | O&M, H&S, etc. | \$(0.01)       |
| Commercial & Industrial | C&I New Custom HVAC                                        | O&M, H&S, etc. | \$0.03         |
| Commercial & Industrial | C&I New Custom Motors (including compressed air)           | O&M, H&S, etc. | \$0.02         |
| Commercial & Industrial | C&I New Custom Process                                     | O&M, H&S, etc. | \$0.09         |
| Commercial & Industrial | C&I New Custom Refrigeration                               | O&M, H&S, etc. | \$0.07         |
| Commercial & Industrial | C&I New Lighting Controls                                  | O&M, H&S, etc. | \$0.11         |
| Commercial & Industrial | C&I New Prescriptive Compressed Air                        | O&M, H&S, etc. | \$0.04         |
| Commercial & Industrial | C&I New Prescriptive HVAC                                  | O&M, H&S, etc. | \$0.14         |
| Commercial & Industrial | C&I New Prescriptive HVAC Controls (inc. EMS & Hotel Occ.) | O&M, H&S, etc. | \$0.19         |
| Commercial & Industrial | C&I Retrocommissioning                                     | O&M, H&S, etc. | \$0.28         |
| Commercial & Industrial | C&I Retrofit CHP                                           | O&M, H&S, etc. | \$0.00         |
| Commercial & Industrial | C&I Retrofit Custom HVAC                                   | O&M, H&S, etc. | \$0.05         |
| Commercial & Industrial | C&I Retrofit Custom Motors (including compressed air)      | O&M, H&S, etc. | \$0.02         |
| Commercial & Industrial | C&I Retrofit Custom Process                                | O&M, H&S, etc. | \$0.10         |
| Commercial & Industrial | C&I Retrofit Custom Refrigeration                          | O&M, H&S, etc. | \$0.08         |

| Sector                  | NEI Description                                                 | NEI Category   | Annual per kWh |
|-------------------------|-----------------------------------------------------------------|----------------|----------------|
| Commercial & Industrial | C&I Retrofit Lighting Controls                                  | O&M, H&S, etc. | \$0.13         |
| Commercial & Industrial | C&I Retrofit Prescriptive Compressed Air                        | O&M, H&S, etc. | \$0.01         |
| Commercial & Industrial | C&I Retrofit Prescriptive HVAC Controls (inc. EMS & Hotel Occ.) | O&M, H&S, etc. | \$0.22         |
| Commercial & Industrial | C&I Retrofit Showerheads & Building Operator Training           | O&M, H&S, etc. | \$0.00         |
| Commercial & Industrial | C&I Retrofit Thermostat                                         | O&M, H&S, etc. | \$0.25         |

**Sources:**

Commercial & Industrial NEIs are based on the following reports:

KEMA, Inc. (2012). *Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy Impacts Study*

DNV GL (2016). *Commercial and Industrial New Construction Non-Energy Impacts Study*.

NMR, DNV, ThreeCubed (2021). *O&M and Non-O&M NEI Study*

**Table B-3: Gas C&I Non-Energy Impacts**

| Sector                  | NEI Description                      | NEI Category                                                                                                                                                   | Annual per kWh | Annual per Therm |
|-------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|
| Commercial & Industrial | C&I NC Compressed Air - Custom       | O&M                                                                                                                                                            | \$0.03         |                  |
| Commercial & Industrial | C&I NC Compressed Air - Prescriptive | O&M                                                                                                                                                            | \$0.04         |                  |
| Commercial & Industrial | C&I NC HVAC - Custom                 | O&M                                                                                                                                                            | \$0.00         |                  |
| Commercial & Industrial | C&I NC Lighting - Custom             | O&M                                                                                                                                                            | \$0.00         |                  |
| Commercial & Industrial | C&I NC Lighting - Prescriptive       | O&M                                                                                                                                                            | \$0.02         |                  |
| Commercial & Industrial | C&I NC Process - Custom              | O&M                                                                                                                                                            | \$0.01         |                  |
| Commercial & Industrial | C&I NC Refrigeration - Custom        | O&M                                                                                                                                                            | \$0.01         |                  |
| Commercial & Industrial | C&I Retro Compressed Air             | Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal | \$0.06         |                  |
| Commercial & Industrial | C&I Retro HVAC - Custom              | Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal | \$0.02         |                  |
| Commercial & Industrial | C&I Retro HVAC - Prescriptive        | Administrative costs, other costs, other labor costs, O&M, rent revenue                                                                                        | \$0.10         | \$1.35           |
| Commercial & Industrial | C&I Retro Lighting - Custom          | Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal | \$0.06         |                  |
| Commercial & Industrial | C&I Retro Lighting - Prescriptive    | Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal                                              | \$0.03         |                  |

| Sector                  | NEI Description                                                             | NEI Category                                                                                                                                                   | Annual per kWh | Annual per Therm |
|-------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|
| Commercial & Industrial | C&I Retro Process                                                           | Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal | \$0.06         |                  |
| Commercial & Industrial | C&I Retro Refrigeration - Custom                                            | Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal | \$0.05         |                  |
| Commercial & Industrial | C&I Retro Refrigeration - Prescriptive                                      | Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal | \$0.05         |                  |
| Commercial & Industrial | CHP Systems                                                                 | Administrative costs, O&M                                                                                                                                      | -\$0.01        |                  |
| Commercial & Industrial | Fuel Cells                                                                  | Stack Replacement                                                                                                                                              |                |                  |
| Commercial & Industrial | C&I - Other, Custom & Building Operator Certification & Codes and Standards | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                                                                |                | \$0.61           |
| Commercial & Industrial | C&I - New Bldg - Prescriptive - HVAC/Heat Recovery, Gas                     | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                                                                |                | \$0.24           |
| Commercial & Industrial | C&I - New Bldg - Prescriptive - Other Gas Heating, Gas                      | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                                                                |                | \$0.05           |
| Commercial & Industrial | C&I - New Bldg - Prescriptive - Boilers, Gas                                | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                                                                |                | -\$0.08          |
| Commercial & Industrial | C&I - New Bldg - Prescriptive - Commercial Kitchen, Gas                     | HS&E, Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                                                          |                | \$5.10           |
| Commercial & Industrial | C&I - New Bldg - Custom - Commercial Kitchen, Gas                           | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                                                                |                | \$3.40           |

| Sector                  | NEI Description                                        | NEI Category                                                                                    | Annual per kWh | Annual per Therm |
|-------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------|------------------|
| Commercial & Industrial | C&I - Custom Heating Systems & Controls                |                                                                                                 |                | -\$0.05          |
| Commercial & Industrial | C&I - Custom Process - New                             |                                                                                                 |                | -\$0.05          |
| Commercial & Industrial | C&I - Custom Process - Retrofit                        |                                                                                                 |                | -\$0.05          |
| Commercial & Industrial | C&I - Water Heating - Midstream                        |                                                                                                 |                | \$0.08           |
| Commercial & Industrial | C&I - Prescriptive Steam Trap & Pipe Wrap              |                                                                                                 |                | \$0.08           |
| Commercial & Industrial | C&I - Custom Hot Water - New                           |                                                                                                 |                | \$0.35           |
| Commercial & Industrial | C&I - Custom Steam & Hot Water - Retrofit              |                                                                                                 |                | \$0.35           |
| Commercial & Industrial | C&I - Showerheads & Aerators - Retrofit                |                                                                                                 |                | \$0.36           |
| Commercial & Industrial | C&I - Custom Ozonated Laundry                          |                                                                                                 |                | \$0.44           |
| Commercial & Industrial | C&I - Ductwork - Retrofit                              |                                                                                                 |                | \$0.59           |
| Commercial & Industrial | C&I - Condensing Heating Systems                       |                                                                                                 |                | \$0.85           |
| Commercial & Industrial | C&I - Pipe Wrap & Boiler Reset Controls - Retrofit     |                                                                                                 |                | \$0.86           |
| Commercial & Industrial | C&I - Prescriptive HVAC, Gas                           |                                                                                                 |                | \$2.80           |
| Commercial & Industrial | C&I - HVAC, Electrification                            |                                                                                                 | \$0.14         |                  |
| Commercial & Industrial | C&I - Retrocommissioning, Gas                          |                                                                                                 |                | \$1.44           |
| Commercial & Industrial | C&I - Existing - Prescriptive - HVAC, Gas              | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal |                | \$1.35           |
| Commercial & Industrial | C&I - Existing - Prescriptive - Building Envelope, Gas | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal |                | \$3.62           |

| Sector                  | NEI Description                                                | NEI Category                                                                                                      | Annual per kWh | Annual per Therm |
|-------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|----------------|------------------|
| Commercial & Industrial | C&I - Existing - Custom - HVAC, Gas                            | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                   |                | -\$0.04          |
| Commercial & Industrial | C&I - Envelope, Comprehensive Design, & Comprehensive Retrofit | Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal                   |                | \$0.48           |
| Commercial & Industrial | C&I Lighting - Prescriptive, Gas                               | Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal | \$0.03         |                  |
| Commercial & Industrial | C&I Lighting - Custom, Gas                                     | Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal | \$0.06         |                  |
| Commercial & Industrial | C&I - Custom Foodservice                                       |                                                                                                                   |                | \$3.40           |

**Sources:**

Commercial & Industrial NEIs are based on the following reports:

KEMA, Inc. (2012). *Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy Impacts Study*

DNV GL (2016). *Commercial and Industrial New Construction Non-Energy Impacts Study*.

NMR, DNV, ThreeCubed (2021). *O&M and Non-O&M NEI Study*



## Appendix C: Acronyms

| <b>ACRONYM</b> | <b>DESCRIPTION</b>                                                                    |
|----------------|---------------------------------------------------------------------------------------|
| AC             | Air Conditioning                                                                      |
| AFUE           | Annual Fuel Utilization Efficiency (see the Glossary)                                 |
| AHU            | Air Handling Unit                                                                     |
| Btu            | British Thermal Unit (see the Glossary)                                               |
| CF             | Coincidence Factor (see the Glossary)                                                 |
| CFL            | Compact Fluorescent Lamp                                                              |
| CHP            | Combined Heat and Power                                                               |
| COP            | Coefficient of Performance (see the Glossary)                                         |
| DCV            | Demand Controlled Ventillation                                                        |
| DHW            | Domestic Hot Water                                                                    |
| DOER           | Department of Energy Resources                                                        |
| DSM            | Demand Side Management (see the Glossary)                                             |
| ECM            | Electrically Commutated Motor                                                         |
| EER            | Energy Efficiency Ratio (see the Glossary)                                            |
| EF             | Efficiency Factor                                                                     |
| EFLH           | Equivalent Full Load Hours (see the Glossary)                                         |
| ES             | ENERGY STAR® (see the Glossary)                                                       |
| FCM            | Forward Capacity Market                                                               |
| FR             | Free-Ridership (see the Glossary)                                                     |
| HE             | High-Efficiency                                                                       |
| HID            | High-Intensity Discharge (a lighting technology)                                      |
| HP             | Horse Power (see the Glossary)                                                        |
| HSPF           | Heating Seasonal Performance Factor (see the Glossary)                                |
| HVAC           | Heating, Ventilating, and Air Conditioning                                            |
| ISO            | Independent System Operator                                                           |
| ISR            | In-Service Rate (see the Glossary)                                                    |
| kW             | Kilowatt, a unit of electric demand equal to 1,000 watts                              |
| kWh            | Kilowatt-Hour, a unit of energy (1 kilowatt of power supplied for one hour)           |
| LED            | Light-Emitting Diode (one type of solid-state lighting)                               |
| LCD            | Liquid Crystal Display (a technology used for computer monitors and similar displays) |
| MMBtu          | One million British Thermal Units (see “Btu” in the Glossary)                         |
| MW             | Megawatt – a measure of electric demand equal to 1,000 kilowatts                      |
| MWh            | Megawatt-hour – a measure of energy equal to 1,000 kilowatt-hours                     |
| NEB            | Non-Electric Benefit (see the Glossary)                                               |
| NEI            | Non-Energy Impact                                                                     |
| NE-ISO         | New England Independent System Operator                                               |
| NTG            | Net-to-Gross (see the Glossary)                                                       |
| O&M            | Operations and Maintenance                                                            |
| PA             | Program Administrator (see the Glossary)                                              |
| RR             | Realization Rate (see the Glossary)                                                   |
| SEER           | Seasonal Energy Efficiency Ratio (see the Glossary)                                   |
| SO             | Spillover (see the Glossary)                                                          |
| SPF            | Savings Persistence Factor (see the Glossary)                                         |
| SSL            | Solid-State Lighting (e.g., LED lighting)                                             |
| VSD            | Variable-Speed Drive                                                                  |

## Appendix D: Glossary

This glossary provides definitions as they are applied in this TRM for Massachusetts' energy efficiency programs. Alternate definitions may be used for some terms in other contexts.

| TERM                             | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Adjusted Gross Savings           | Gross savings (as calculated by the measure savings algorithms) that have been subsequently adjusted by the application of all impact factors except the net-to-gross factors (free-ridership and spillover). For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.                                                                                                                                                                                                                                                                                                                                                           |
| AFUE                             | Annual Fuel Utilization Efficiency. The measure of seasonal or annual efficiency of a furnace or boiler. AFUE takes into account the cyclic on/off operation and associated energy losses of the heating unit as it responds to changes in the load, which in turn is affected by changes in weather and occupant controls.                                                                                                                                                                                                                                                                                                                                                |
| Baseline Efficiency              | The level of efficiency of the equipment that would have been installed without any influence from the program or, for retrofit cases where site-specific information is available, the actual efficiency of the existing equipment.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Btu                              | British thermal unit. A Btu is approximately the amount of energy needed to heat one pound of water by one degree Fahrenheit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Coefficient of Performance (COP) | Coefficient of Performance is a measure of the efficiency of a heat pump, air conditioner, or refrigeration system. A COP value is given as the Btu output of a device divided by the Btu input of the device. The input and output are determined at AHRI testing standards conditions designed to reflect peak load operation.                                                                                                                                                                                                                                                                                                                                           |
| Coincidence Factor (CF)          | Coincidence Factors: represent the fraction of connected load expected to occur concurrent to a particular system peak period; separate CF are found for summer and winter peaks. The CF given in the TRM includes both coincidence and diversity factors multiplied into one number. Coincidence Factors are provided for peak periods defined by the NE-ISO for FCM purposes and calculated consistent with the FCM methodology.                                                                                                                                                                                                                                         |
| Connected Load kW Savings        | The connected load kW savings is the power saved by the equipment while in use. In some cases the savings reflect the maximum power draw of equipment at full load. In other cases the connected load may be variable, which must be accounted for in the savings algorithm.                                                                                                                                                                                                                                                                                                                                                                                               |
| Deemed Savings                   | Savings values (electric, fossil fuel and/or non-energy benefits) determined from savings algorithms with assumed values for all algorithm parameters. Alternatively, deemed savings values may be determined from evaluation studies. A measure with deemed savings will have the same savings per unit since all measure assumptions are the same. Deemed savings are used by program administrators to report savings for measures with well-defined performance characteristics relative to baseline efficiency cases. Deemed savings can simplify program planning and design, but may lead to over- or under-estimation of savings depending on product performance. |

|                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Deemed Calculated Savings     | Savings values (electric, fossil fuel and/or non-energy benefits) that depend on a standard savings algorithm and for which at least one of the algorithm parameters (e.g., hours of operation) is project specific.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Demand Savings                | The reduction in demand due to installation of an energy efficiency measure, usually expressed as kW and measured at the customer's meter (see Connected Load kW Savings).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Demand Side Management (DSM)  | Strategies used to manage energy demand including energy efficiency, load management, fuel substitution, and load building.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Diversity                     | A characteristic of a variety of electric loads whereby individual maximum demands occur at different times. For example, 50 efficient light fixtures may be installed, but they are not necessarily all on at the same time. See Coincidence Factor.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Diversity Factor              | This TRM uses Coincidence Factors: that incorporate diversity (See Coincidence Factor), thus this TRM has no separate diversity factors. A diversity factor is typically calculated as: 1) the percent of maximum demand savings from energy efficiency measures available at the time of the company's peak demand, or 2) the ratio of the sum of the demands of a group of users to their coincident maximum demand.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| End Use                       | <p>Refers to the category of end use or service provided by a measure or technology (e.g., lighting, cooling, etc.). For the purpose of this manual, end uses with their codes include:</p> <p style="text-align: center;">             ALght Lighting      HEUBe Behavior<br/>             HVAC HVAC Ienvl      Insulation &amp; Air Sealing<br/>             CMoDr Motors &amp; Drives      JGchp Combined Heat &amp; Power<br/>             DRefr Refrigeration      KSdhw Solar Hot Water<br/>             EHoWaHot Water      LDmdR Demand Response<br/>             FComACompressed AirMPvEl Photovoltaic Panels<br/>             GProc Process*         </p> <p>*For residential measures, "process" is used for products that have low savings, such as consumer electronics, or do not conform to existing end use categories. For commercial and industrial measures, "process" is used for systematic improvements to manufacturing or pump systems, or efficient models of specialty equipment not covered in other end uses.</p> |
| Energy Efficiency Ratio (EER) | The Energy Efficiency Ratio is a measure of the efficiency of a cooling system at a specified peak, design temperature, or outdoor temperature. In technical terms, EER is the steady-state rate of heat energy removal (i.e. cooling capacity) of a product measured in Btuh output divided by watts input.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| ENERGY STAR® (ES)             | Brand name for the voluntary energy efficiency labeling initiative sponsored by the U.S. Environmental Protection Agency.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Energy Costing Period         | A period of relatively high or low system energy cost, by season. The energy periods defined by ISO-NE are:<br>Summer Peak: 6am–10pm, Monday–Friday (except ISO holidays), June–September                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

|                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | <p>Summer Off-Peak: Summer hours not included in the summer peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, June–September</p> <p>Winter Peak: 6am–10pm, Monday–Friday (except ISO holidays), January–May and October–December</p> <p>Winter Off-Peak: Winter hours not included in the winter peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, January–May and October–December.</p> |
| Equivalent Full Load Hours (EFLH)          | The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).                                                                                                                                                                                                                                                                                                 |
| Free Rider                                 | A customer who participates in an energy efficiency program, but would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available.                                                                                                                                                                                                                                        |
| Free-Ridership Rate                        | The percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.                                                                                                                                                                                                                                                                                                                               |
| Gross kW                                   | Expected demand reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.                                                                                                                                                                                                                                                                                                                    |
| Gross kWh                                  | Expected kWh reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.                                                                                                                                                                                                                                                                                                                       |
| Gross Savings                              | A saving estimate calculated from objective technical factors. In this TRM, “gross savings” are calculated with the measure algorithms and do not include any application of impact factors. Once impact factors are applied, the savings are called “Adjusted Gross Savings”. For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.                                                                                  |
| High Efficiency (HE)                       | Refers to the efficiency measures that are installed and promoted by the energy efficiency programs.                                                                                                                                                                                                                                                                                                                                                               |
| Horsepower (HP)                            | A unit for measuring the rate of doing work. One horsepower equals about three-fourths of a kilowatt (745.7 watts).                                                                                                                                                                                                                                                                                                                                                |
| Heating Seasonal Performance Factor (HSPF) | A measure of the seasonal heating mode efficiencies of heat pumps expressed as the ratio of the total heating output to the total seasonal input energy.                                                                                                                                                                                                                                                                                                           |
| Impact Factor                              | Generic term for a value used to adjust the gross savings estimated by the savings algorithms in order to reflect the actual savings attributable to the efficiency program. In this TRM, impact factors include realization rates, in-service rates, savings persistence, peak demand coincidence factors, free-ridership, spillover and net-to-gross factors. See the section on Impact Factors for more detail.                                                 |
| In-Service Rate                            | The percentage of units that are actually installed. For example, efficient lamps may have an in-service rate less than 100% since some lamps are purchased as replacement units and are not immediately installed. The in-service rate for most measures is 100%.                                                                                                                                                                                                 |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measure Life                 | The number of years that an efficiency measure is expected to garner savings. These are generally based on engineering lives, but sometimes adjusted based on observations of market conditions.                                                                                                                                                                                                                                                                              |
| Lost Opportunity             | Refers to a measure being installed at the time of planned investment in new equipment or systems. Often this reflects either new construction, renovation, remodeling, planned expansion or replacement, or replacement of failure.                                                                                                                                                                                                                                          |
| Measure                      | A product (a piece of equipment), combination of products, or process designed to provide energy and/or demand savings. Measure can also refer to a service or a practice that provides savings. Measure can also refer to a specific combination of technology and market/customer/practice/strategy (e.g., direct install low income CFL).                                                                                                                                  |
| Net Savings                  | The final value of savings that is attributable to a program or measure. Net savings differs from gross savings (or adjusted gross savings) because it includes adjustments due to free-ridership and/or spillover. Net savings is sometimes referred to as "verified" or "final" savings. For more detail see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.                                                                                  |
| Net-to-Gross Ratio           | The ratio of net savings to the adjusted gross savings (for a measure or program). The adjusted gross savings include any adjustment by the impact factors other than free-ridership or spillover. Net-to-gross is usually expressed as a percent.                                                                                                                                                                                                                            |
| Non-Electric Benefits (NEBs) | Quantifiable benefits (beyond electric savings) that are the result of the installation of a measure. Fossil fuel, water, and maintenance are examples of non-electric benefits. Non-electric benefits can be negative (i.e. increased maintenance or increased fossil fuel usage which results from a measure) and therefore are sometimes referred to as "non-electric impacts".                                                                                            |
| Non-Participant              | A customer who is eligible to participate in a program, but does not. A non-participant may install a measure because of a program, but the installation of the measure is not through regular program channels; as a result, their actions are normally only detected through evaluations.                                                                                                                                                                                   |
| On-Peak kW                   | See Summer/Winter On-peak kW                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Operating Hours              | Hours that a piece of equipment is expected to be in operation, not necessarily at full load (typically expressed per year).                                                                                                                                                                                                                                                                                                                                                  |
| Participant                  | A customer who installs a measure through regular program channels and receives any benefit (i.e. incentive) that is available through the program because of their participation. Free-riders are a subset of this group.                                                                                                                                                                                                                                                    |
| Prescriptive Measure         | A prescriptive measure is generally offered by use of a prescriptive form with a prescribed incentive based on the parameters of the efficient equipment or practice.                                                                                                                                                                                                                                                                                                         |
| Program Administrator (PA)   | Massachusetts electric and natural gas distribution companies and municipal aggregators with certified energy plans. The Massachusetts PAs are The Berkshire Gas Company, Cape Light Compact JPE, Fitchburg Gas & Electric Light Company d/b/a Unitil, Liberty Utilities (New England Natural Gas Company) Corp. d/b/a Liberty, Massachusetts Electric Company, Nantucket Electric Company, Boston Gas Company and former Colonial Gas Company, each d/b/a National Grid, and |

|                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                         | NSTAR Electric Company, NSTAR Gas Company and Eversource Gas Company of Massachusetts, each d/b/a Eversource Energy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Realization Rate (RR)                   | The ratio of measure savings developed from impact evaluations to the estimated measure savings derived from the TRM savings algorithms. This factor is used to adjust the estimated savings when significant justification for such adjustment exists. The components of the realization rate are described in detail in the section on Impact Factors.                                                                                                                                                                                                                                                                                |
| Retrofit                                | The replacement of a piece of equipment or device before the end of its useful or planned life for the purpose of achieving energy savings. "Retrofit" measures are sometimes referred to as "early retirement" when the removal of the old equipment is aggressively pursued.                                                                                                                                                                                                                                                                                                                                                          |
| Savings Persistence Factor (SPF)        | Percentage of first-year energy or demand savings expected to persist over the life of the installed energy efficiency equipment. The SPF is developed by conducting surveys of installed equipment several years after installation to determine the operational capability of the equipment. In contrast, <i>measure persistence</i> takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor. |
| Seasonal Energy Efficiency Ratio (SEER) | A measurement of the efficiency of a central air conditioner over an entire season. In technical terms, SEER is a measure of equipment the total cooling of a central air conditioner or heat pump (in Btu) during the normal cooling season as compared to the total electric energy input (in watt-hours) consumed during the same period.                                                                                                                                                                                                                                                                                            |
| Seasonal Peak kW                        | See Summer/Winter Seasonal Peak kW, and Summer/Winter On-Peak Peak kW.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Sector                                  | A system for grouping customers with similar characteristics. For the purpose of this manual, the sectors are Commercial and Industrial (C&I), Small Business, Residential, and Low Income.                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Spillover Rate                          | The percentage of savings attributable to the program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of (a) participants in the program who install additional energy efficient measures outside of the program as a result of hearing about the program and (b) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program.                                                                                                                                                                                        |
| Summer/Winter On-Peak kW                | The average demand reduction during the summer/winter on-peak period. The summer on-peak period is 1pm-5pm on non-holiday weekdays in June, July and August; the winter on-peak period is 5pm-7pm on non-holiday weekdays in December and January.                                                                                                                                                                                                                                                                                                                                                                                      |
| Summer/Winter Seasonal Peak kW          | The demand reduction occurring when the actual, real-time hourly load for Monday through Friday on non-holidays, during the months of June, July, August, December, and January, as determined by the ISO, is equal to or greater than 90% of the most recent 50/50 system peak load forecast, as determined by the ISO, for the applicable summer or winter season.                                                                                                                                                                                                                                                                    |

|      |                                                                              |
|------|------------------------------------------------------------------------------|
| Ton  | Unit of measure for determining cooling capacity. One ton equals 12,000 Btu. |
| Watt | A unit of electrical power. Equal to 1/1000 of a kilowatt.                   |