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[1].

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.

[1] 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: Assure collaboration and consensus by the PAs regarding updates Assure updates are compiled from the PAs and incorporated 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. Identify needed updates Coordinate with other PAs on all updates File updates with the Department
Department of Energy Resources	Provide one representative to the Coordinating Committee Assure coordination with PA submissions of program plans and reported savings

Update Cycle

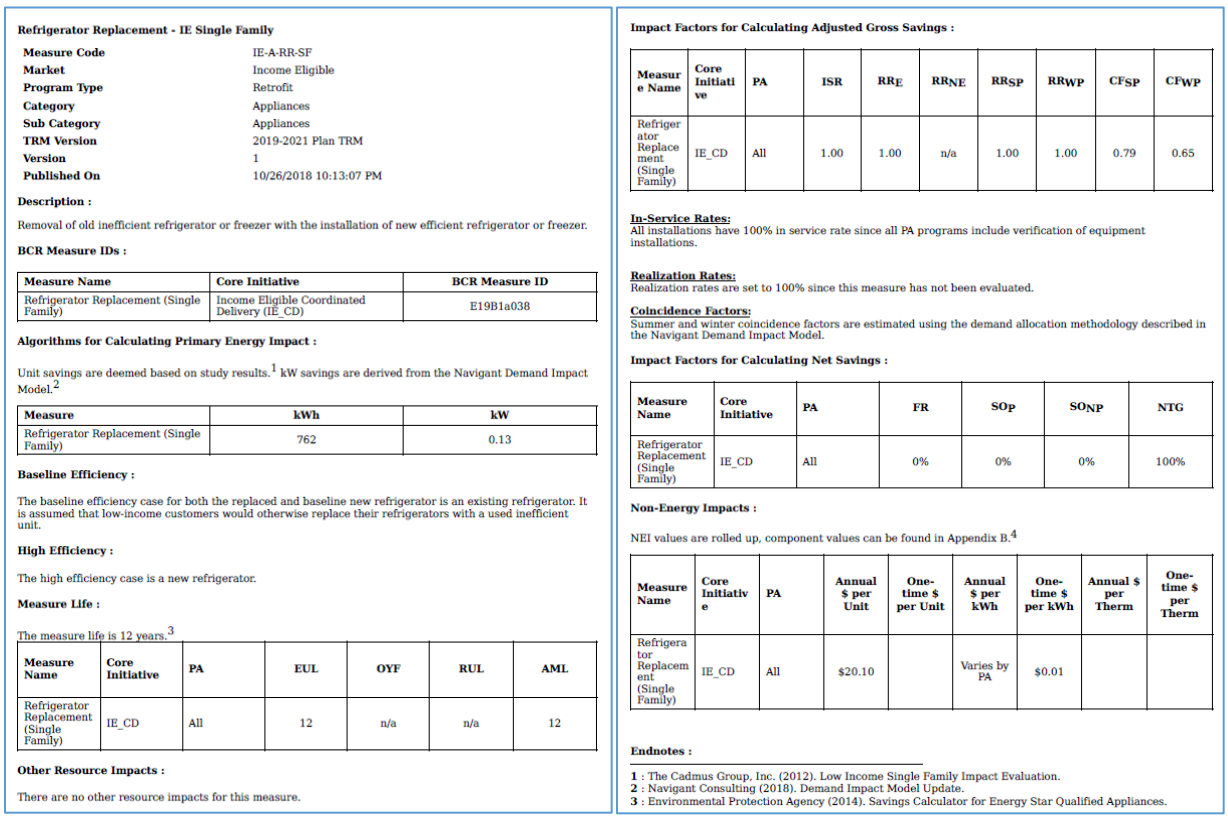
Per the Department, starting in 2022, new evaluation results will be applied on a prospective only basis instead of being applied both retrospectively and prospectively. The PAs will update gross savings assumptions and net and gross impact factors each year based on the latest evaluation studies and 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.[2]

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.



Refrigerator Replacement - IE Single Family

Measure Code	IE-A-RR-SF
Market	Income Eligible
Program Type	Retrofit
Category	Appliances
Sub Category	Appliances
TRM Version	2019-2021 Plan TRM
Version	1
Published On	10/26/2018 10:13:07 PM

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)	E19B1a038

Algorithms for Calculating Primary Energy Impact :

Unit savings are deemed based on study results.[1] kW savings are derived from the Navigant Demand Impact Model.[2]

Measure	kWh	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 refrigerator.

Measure Life :

The measure life is 12 years.[3]

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 for this measure.

Impact Factors for Calculating Adjusted Gross Savings :

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Replacement (Single Family)	IE_CD	All	1.00	1.00	n/a	1.00	1.00	0.79	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 Navigant Demand Impact Model.

Impact Factors for Calculating Net Savings :

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Refrigerator Replacement (Single Family)	IE_CD	All	0%	0%	0%	100%

Non-Energy Impacts :

NEI values are rolled up, component values can be found in Appendix B.[4]

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		

Endnotes :

1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation.
2 : Navigant Consulting (2018). Demand Impact Model Update.
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:

[2] 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:
$\Delta kW = \left(Watts_{BASE} - Watts_{EE}\right)/1000$

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_P) and **non-participant spillover** (SO_{NP}).

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

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

Standard Net-to-Gross Formulas

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

Calculation of Net Annual Electric Energy Savings

$$adj\_gross\_kWh = gross\_kWh \times RR_E \times SPF \times ISR$$
$$net\_kWh = adj\_gross\_kWh \times NTG$$

Calculation of Net Summer Electric Peak Demand Coincident kW Savings

$$adj\_gross\_kW_{SP} = gross\_kW \times RR_{SP} \times SPF \times ISR \times CF_{SP}$$
$$net\_kW_{SP} = adj\_gross\_kW_{SP} \times NTG$$

Calculation of Net Winter Electric Peak Demand Coincident kW Savings

$$adj\_gross\_kW_{WP} = gross\_kW \times RR_{WP} \times SPF \times ISR \times CF_{WP}$$
$$net\_kW_{WP} = adj\_gross\_kW_{WP} \times NTG$$

Calculation of Net Annual Natural Gas Energy Savings

$$adj\_gross\_MMBtu = gross\_MMBtu \times RR_{NE} \times SPF \times ISR$$
$$net\_MMbtu = adj\_gross\_MMBtu \times NTG$$

Depending on the evaluation study methodology:

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

Where:

$Gross\_kWh$	=	Gross Annual kWh Savings
adj_gross_kWh	=	Adjusted Gross Annual kWh Savings
net_kWh	=	Net Annual kWh Savings
$Gross\_kW_{SP}$	=	Gross Connected kW Savings (summer peak)
$adj\_gross\_kW_{SP}$	=	Adjusted Gross Connected kW Savings (summer peak)
$Gross\_kW_{WP}$	=	Gross Connected kW Savings (winter peak)
$adj\_gross\_kW_{WP}$	=	Adjusted Gross Connected kW Savings (summer peak)
net_kW_{SP}	=	Adjusted Gross Connected kW Savings (winter peak)

net_kW_{WP}	=	Net Coincident kW Savings (winter peak)
Gross_MMBtu	=	Gross Annual MMBtu Savings
adj_gross_MMBtu	=	Adjusted Gross Annual MMBtu Savings
net_MMBtu	=	Net Annual MMBtu Savings
SPF	=	Savings Persistence Factor
ISR	=	In-Service Rate
CF_{SP}	=	Peak Coincidence Factor (summer peak)
CF_{WP}	=	Peak Coincidence Factor (winter peak)
RR_E RR_{NE}	= =	Realization Rate, electric(kWh) Realization Rate, non-electric (MMBtu)
RR_{SP}	=	Realization Rate for summer peak kW
RR_{WP}	=	Realization Rate for winter peak kW
NTG	=	Net-to-Gross Ratio
FR	=	Free-Ridership Factor
SO_P	=	Participant Spillover Factor
SO_{NP}	=	Non-Participant Spillover Factor

Calculations of Coincident Peak Demand kW Using "Seasonal Peak" Coincidence Factors

The formulas above for peak demand kW savings use the "on-peak" Coincidence Factors: (CF_{SP}, CF_{WP}), which apply the "on-peak" coincidence methodology as allowed for submission to the FCM. The alternative methodology is the "seasonal peak" methodology, which uses the identical formulas, but substituting the "seasonal peak" Coincidence Factors for the "on-peak" coincidence factors:

CF_{SSP}	=	Peak Coincidence Factor for Summer Seasonal Peak
CF_{WSP}	=	Peak Coincidence Factor for Winter Seasonal Peak

1. Residential Efficiency Measures

1.1. Appliance - Clothes Dryer

Measure Code	RES-A-CD
Market	Residential
Program Type	Retrofit
Category	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[1]
ENERGY STAR CEF = 3.93[2]
Lbs/load = 8.45[3]
Loads/Year = 283[4]

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[5]

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.[6]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

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.[8]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[9]

2022

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dryer (Energy Star)	RES_RETAIL	All	0.47	0.00	0.00	0.53

2023

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dryer (Energy Star)	RES_RETAIL	All	0.48	0.00	0.00	0.52

2024

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-PL-DH
Market	Residential
Program Type	Retrofit
Category	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:

ΔkWh New = Dehumidification Load * ((1/EffBase)-(1/EffEE))
ΔkWh Recycling = Dehumidification Load * ((1/EffRetire)-(1/EffBase))

Where:
Dehumidification Load = Typical annual moisture removal, in Liters/year. Average annual dehumidification load is 1,520 Liters/year.[1]
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.[2]

Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3]

Measure Name	ΔkWh	ΔkW
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).[4] 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).[5]

High Efficiency:

The high efficiency case for rebates on new equipment is an ENERGY STAR® unit (3.3 Liters/kWh).[6] 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. [7]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[8] 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.[9]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[10] [11]

2022

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dehumidifier	RES_RETAIL	All	0.51	0.00	0.00	0.49

2023

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dehumidifier	RES_RETAIL	All	0.53	0.00	0.00	0.47

2024

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dehumidifier	RES_RETAIL	All	0.55	0.00	0.00	0.45

2022-2024

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-A-ERCW
Market	Residential
Program Type	Retrofit
Category	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:

ΔkWh = [(Capacity x 1/IMEFbase x Ncycles) * (%CWkwhbase + %DHWkwhbase + %Dryerkwhbase)]
- [(Capacity x 1/IMEFeff x Ncycles) x (%CWkwheff + %DHWkwheff + %Dryerkwheff)]
ΔMMBTUs = [(Capacity x 1/MEFbase x Ncycles) x ((%DHWffbase x r_eff) + %Dryerffbase] - [(Capacity x 1/MEFeff x Ncycles) x (%DHWffeff x r_eff) + %Dryergaseff]xMMBTU_convert

Where:
Capacity = washer volume in ft3.
IMEF = Integrated Modified Energy Factor and is measured in ft3 /kWh/cycle
Ncycles = 283 loads per year[1]
%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[2]

	% 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	3.1
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.[3]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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 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^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/ft3

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.[4]

Measure Life:

The effective useful life of the new clothes washer is assumed to be 12 years.[5] 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:

ΔWater (gallons) = (Capacity * (IWFbase - IWFeff)) * 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

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_P	SO_{NP}	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 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

Measure Code	RES-A-RFR
Market	Residential
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW
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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Impact Factors for Calculating Net Savings:

Net-to-gross factors are based on study results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-PL-RAC
Market	Residential
Program Type	Time of Sale
Category	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.[1] 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/$Watt_{dust}$.[2]

High Efficiency:

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

Measure Life:

The measure life is 9 years.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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).[4]

2022

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Cleaner	RES_RETAIL	All	0.34	0.00	0.00	0.66

2023

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Cleaner	RES_RETAIL	All	0.36	0.00	0.00	0.64

2024

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-CM-REF
Market	Residential
Program Type	Lost Opportunity
Category	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.[1]

Measure	ΔkWh[2]	ΔkW
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 refrigerant.

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.[3]

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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Assumed 10% free-ridership.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-O-HER
Market	Residential
Program Type	Behavior
Category	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.

$\Delta kWh = (kWh_{BASE})\ (\%SAVE)$
$\Delta MMBtu = (MMBtu_{BASE})\ (\%SAVE)$

Where:
Unit = One participant household.
$kWh/MMBTU_{BASE}$ = Baseline energy consumption kWh/MMBTu.
%SAVE = Energy savings percent per program participant.

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.[1]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1] All other PA realization rates are based on 2015 evaluation results.[2]

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.[3]

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

Measure Code	RES-BS-AS
Market	Residential
Program Type	Retrofit
Category	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.[1]

High Rise:

Unit savings are calculated using the following algorithms and assumptions:
MMBtu = (Vol x ΔACH x 0.018 x HDD60 x 24) / (1,000,000 * ηheating)
kWh = MMBtu * 293.1
kW = kWh x kW/kWh

Where:
Vol = [ft3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
ΔACH = [ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value[2] or Blower Door Test)
HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below.
ηheating = [AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)
24 = Conversion factor: 24 hours per day
0.018 = [Btu/ft3- ºF] Air heat capacity: The specific heat of air (0.24 Btu/ºF.lb) times the density of air (0.075 lb/ft3)
1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu
293.1 = Conversion factor: 293.1 kWh / MMBtu
kW/kWh = Average kW reduction per kWh reduction: 0.00073 kW/kWh[3]

Hours:
Heating hours are characterized by the heating degree days for the facility.[4] 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.[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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, 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[6] while High Rise is based on Multifamily evaluation results.[7]

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.[8]

Impact Factors for Calculating Net Savings:

Net-to-gross factors are based on evaluation results.[9] Moderate Income Qualified use the same NTG values.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-BS-I
Market	Residential
Program Type	Retrofit
Category	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[1] :

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:

$MMBtu = ((1/R_{exist} - 1/R_{new})*HDD * 24 * Area) / (1000000 * \eta_{heat})$
$kWh = MMBtu * 293.1$
$kW = kWh * kW/kWh_{heat}$

Where:
R_{exist} = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft2-°F/Btuh
R_{new} = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft2-°F/Btuh
Area = Square footage of insulated area
η_{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_{heat} = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

If Facility has central cooling then also calculate air conditioning savings:
$kWh_{cool} = ((1/R_{exist} - 1/R_{new}) * CDH * DUA * Area) / (1000 Btu/kBtu * \eta_{cool})$

$kW = kWh * kW/kWh_{cool}$

Where:
R_{exist} = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft2-°F/Btuh
R_{new} = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft2-°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[2]
Area = Square footage of insulated area
η_{cool} = Efficiency of air conditioning equipment (SEER), site specific
CDH = Cooling Degree Hours; dependent on location, see table below
kW/kWh_{cool} = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

Hours:
Heating hours are characterized by the heating degree days for the facility.[3] 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 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).[4]

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 (Rexisit) plus the R-value of the added insulation.

Measure Life:

The measure life is 25 years.[5]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6] [7]

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.[8]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[9]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-BS-WIN
Market	Residential
Program Type	Early Replacement
Category	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[1] 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 kWh
Single Pane with storm electric resistance heating savings are calculated using the following:
(AEHb2-AEHes3)*SqFt = 83.7 kWh
Single Pane 'tight' fossil fuel heating savings are calculated using the following:
(AGUb-AGUes3)*SqFt = 1.08 MMBtu
Single Pane with storm fossil fuel heating savings are calculated using the following:
(AGUb2-AGUes3)*SqFt = 0.42 MMBtu

where:
AEHb=22.02 (see Annual Energy Usage table)
AEHb2=10.79 (see Annual Energy Usage table)
AEHes3=3.64 (see Annual Energy Usage table)
AGUb=0.111 (see Annual Energy Usage table)
AGUb2=0.054 (see Annual Energy Usage table)
AGUes3=0.018 (see Annual Energy Usage table)
SqFt= Assumed 11.7 square feet of area per window based on an average window size of 31.5"x53.5"

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 kWh
Energy Star double pane fossil fuel heating savings are calculated using the following:
(AGUes2-AGUes3)*SqFt = 0.12 MMBtu

where:
AEHes2=5.66 (see Annual Energy Usage table)
AEHes3=3.64 (see Annual Energy Usage table)
AGUes2=0.028 (see Annual Energy Usage table)
AGUes3=0.018 (see Annual Energy Usage table)
SqFt= Assumed 11.7 square feet of area per window based on an average window size of 31.5"x53.5"

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

Cooling early replacement savings are calculated using the following: (AECb2-AECes3)*SqFt = 14.27 kWh
Cooling savings after the remaining life are calculated using the following: (AECes2-AECes3)*SqFt = 1.64 kWh
AECb2=2.57 (see Annual Energy Usage table)
AECes2=1.49 (see Annual Energy Usage table)
AECes3=1.35 (see Annual Energy Usage table)
SqFt= Assumed 11.7 square feet of area per window based on an average window size of 31.5"x53.5"

Annual Energy Usage

Window /Sliding Glass Door Type	Annual Electric Heating Usage AEH (kWh/ft[5])	Annual Electric Cooling Usage AEC (kWh/ft[6])	Annual Fossil Fuel Usage AGU (MMBtu/ft[7])
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.[4] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

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_P	SO_{NP}	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.[6]

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

Measure Code	RES-FS-ISP
Market	Residential
Program Type	Lost Opportunity
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	Core Initiative	ΔkWh	ΔkW
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.[3]

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)[4]
Induction Stove (Propane)	RES_RETAIL	All	2.10

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-CM-CMRCD
Market	Residential
Program Type	Retrofit
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1]

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.[2]

Impact Factors for Calculating Net Savings:

Net-to-gross factors are based on evaluation results.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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

Measure Code	RES-DR-ADR
Market	Residential
Program Type	Active Demand Response
Category	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.[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 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.[3]

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.[4, 5]

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 x Average Temperature °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.[6] 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.[7, 8]

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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 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 2020_Guidehouse_Residential_Energy_Storage_Demand_Response_Winter_Season

1.14. HVAC - Air Source Central Heat Pump

Measure Code	RES-HVAC-ASHP
Market	Residential
Program Type	Early Retirement, Replace on Burnout, Retrofit
Category	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):

$\Delta kWh/= \Delta kWh_{cool} + \Delta kWh_{heat}$ = [Tons*12kBtu/hr/Ton x $(1/SEER_{BASE} - 1/SEER_{EE})$ x $HOURS_C$] + [Tons*12kBtu/hr/Ton x $(1/HSPF_{BASE} - 1/HSPF_{EE})$ X $HOURS_H$]
$\Delta kW = \max (\Delta kW_{cool}, \Delta kW_{heat})$
$\Delta kW_{cool} = \Delta kWh_{cool} \times$ Annual Maximum Demand Factor (cool)
$\Delta kW_{heat} = \Delta kWh_{heat} \times$ Annual Maximum Demand Factor (heat)

Where:
Unit = Savings per outdoor unit
Tons = Capacity of HP equipment
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline HP equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of new efficient HP equipment.
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline HP equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of new efficient HP equipment.
$Hours_C$ = Equivalent Full Load Hours (EFLH) for cooling
$Hours_H$ = 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 [1]

Measure Name	Energy Type	Average SEER[2]	Average HSPF[3]	Tons	Hours[2]	ΔkWh/ Ton	Annual Max Demand Factor[3]	ΔkW
Central Heat Pump, No Integrated Controls	Electric	17.6	9.81	3.03	419 (cool) 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) 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.[7] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Central Heat Pump, No Integrated Controls[8]	RES_RETAIL	All	0.34	0.12	0.10	0.88
Moderate Income Qualified - Central Heat Pump, No Integrated Controls[9]	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.[9]

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

Measure Code	RES-HVAC-BSC
Market	Residential
Program Type	Retrofit
Category	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.[1]
A Boiler Reset Control is a devise 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: [2] 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	ΔMMBtu
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[4]	Core Initiative	PA	FR	SO_P	SO_{NP}	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:

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

Measure Code	RES-HVAC-CVEO-BAT
Market	Residential
Program Type	Active Demand Response
Category	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.[3] [4]

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.[5] [6]

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{Wp}	CF_{SP}	CF_{WP}
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_p	SO_{NP}	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:

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

Measure Code	RES-HVAC-CVEO-SOLPV
Market	Residential
Program Type	Early Retirement
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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)

Measure Code	RES-HVAC-CACQIV
Market	Residential
Program Type	Time of Sale
Category	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:[1]

$\Delta kWh = Tons \times 12\ kBtu/hr/Ton \times (1/SEER) \times Hours \times 5\%$
$\Delta kW = \Delta kWh \times Annual\ Maximum\ Demand\ Factor$

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%[2]

Savings for Central Air QIV

Measure Name	Energy Type	Average Capacity (tons)[3]	Average SEER[4]	Hours[5]	ΔkWh	Annual Max Demand Factor[6]	ΔkW
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.[7]

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_{NF}	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.[8]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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					

Endnotes:

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

Measure Code	RES-HVAC-CAC
Market	Residential
Program Type	Early Retirement, Replace on Burnout, Retrofit
Category	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:

$\Delta kWh = Tons * 12\ kBtu/hr / Ton \times (1/SEER_{BASE} - 1/SEER_{EE}) \times Hours$
$\Delta kW = \Delta kWh \times Annual\ Maximum\ Demand\ Factor$

Where:
Tons = Cooling capacity of AC equipment
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline AC equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of new efficient AC equipment.
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[1]

Measure Name	Energy Type	Average SEER[2]	Hours[3]	Tons	ΔkWh	Annual Max Demand Factor[4]	ΔkW
Central Air (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.[6] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Central Air[8]	RES_RETAIL	All	0.34	0.22	0	0.88
Moderate Income Qualified - Central Air[9]	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.[10]

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

Measure Code	RES-HVAC-CCBWH
Market	Residential
Program Type	Early Retirement, Retrofit
Category	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.[1] Savings have been adjusted to reflect the mix of replace and failure and early retirement based on study results.[2] The savings below are the adjusted values.[3]

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.[4]

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%). [8]

Measure Life:

The measure life is 20 years.[5] 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. [6]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 [6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [7]

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

Measure Code	RES-HVAC-CFWH
Market	Residential
Program Type	Lost Opportunity, Retrofit
Category	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.[1]

Δ Therms = heating load * (1/AFUEbase – 1/AFUEee) = 584 *(1/0.85 – 1/0.97) = 85 therms.

The water heating load is 139 therms.[2]
Δ Therms = water heating load * (1/UEFbase – 1/UEFee) = 139 *(1/0.63 – 1/0.90) = 66 therms.

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

Measure Name	ΔMMBtu/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[3] 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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 [5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Endnotes:

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

Measure Code	RES-HVAC-WT
Market	Residential
Program Type	Retrofit
Category	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	ΔkWh[1]	ΔkW[2]	Δ 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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5] [6] 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.[7]

Impact Factors for Calculating Net Savings:

Net to gross factors for attached low rise and high rise are based on evaluation results.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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 ½ 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:[1]

Units = Completed job
ΔkWh/Ton = Average annual energy reduction per ton
ΔkW/Ton = Average demand reduction per ton

Savings for Down Size 1/2 Ton:

Measure Name	Energy Type	ΔkWh	ΔkW
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Down Size 1/2 Ton[4]	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

Measure Code	RES-HVAC-DI
Market	Residential
Program Type	Retrofit
Category	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[1]:

Measure Name	**ΔkWh**	**ΔkW**[2]	**Δ 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:
ΔMMBtu = MMBtu x 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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

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.[6]

Impact Factors for Calculating Net Savings:

Net-to-gross factors are from evaluation results.[7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-HVAC-DSAF
Market	Residential
Program Type	Retrofit
Category	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.[1] [2]

Measure Name	ΔkWh	ΔkW[3]	Δ 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[4]
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. [5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

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.[7]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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)

Measure Code	RES-HVAC-MSHPQIV
Market	Residential
Program Type	Time of Sale
Category	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:[1]
$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$ = [Tons x 12kBtu/hr/Ton x (1/SEER) x $HOURS_C$ x 5%] + [Tons x 12kBtu/hr/Ton x (1/HSPF) X $HOURS_H$ x 5%]
$\Delta kWcool = \Delta kWh_{cool} \times$ Annual Maximum Demand Factor (cool)
$\Delta kWheat = \Delta kWh_{heat} \times$ 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
$Hours_C$ = Equivalent Full Load Hours (EFLH) for cooling
$Hours_H$ = EFLH for heating
5% = Average demand reduction of 5%[2]

Savings for Mini Split Heat Pump QIV:

Measure Name	Energy Type	Average Capacity (tons)[3]	Average SEER[4]	Average HSPF[5]	Cooling Hours[6] Heating Hours[7]	ΔkWh	Annual Max Demand Factor	ΔkW
DMSHP QIV	Electric	2.3	19.7	11.2	218 (cool) 535 (heat)	82.3	0.001660 (cool) 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.[8]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
DMSHP 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	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
DMSHP QIV	RES_CD 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. [9]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
DMSHP QIV	RES_CD 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

Measure Code	RES-HVAC-DMHP
Market	Residential
Program Type	Replace on Burnout, Retrofit, Time of Sale
Category	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:

$\Delta kWh/ton = \Delta kWh_{cool} + \Delta kWh_{heat} = [12kBtu/hr/Ton \times (1/SEER_{BASE} - 1/SEER_{EE}) \times HOURS_C] + [12kBtu/hr/Ton \times (1/HSPF_{BASE} - 1/HSPF_{EE}) \times HOURS_H]$

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

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

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

Where:
Unit = Savings per ton
Tons = Capacity of DMSHP equipment
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline DMSHP equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of new efficient DMSHP equipment.
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline DMSHP equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of new efficient DMSHP equipment.
$Hours_C$ = Equivalent Full Load Hours (EFLH) for cooling
$Hours_H$ = 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 [1]

Measure Name	Energy Type	Average Capacity (tons)	Average SEER	Average HSPF	Cooling Hours Heating Hours	ΔkWh	Annual Max Demand Factor[8]	ΔkW
DMSHP, No Integrated Controls	Electric	2.33	19.7	11.2	218 (cool) 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-HVAC-ECMCP
Market	Residential
Program Type	Time of Sale
Category	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.[1]

Measure Name	ΔkWh	ΔkW
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG
Circulator Pump[3]	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

Measure Code	RES-HVAC-BFHW
Market	Residential
Program Type	Retrofit
Category	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 = heating load MMBTUs * (1/AFUE base – 1/AFUEee)

Where:
Heating load = 96.51 MMBTUs

Energy Savings for Primary Impact[1]

Measure Name	ΔMMBtu
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)[2]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG
Heating System, Boiler, Propane (non-condensing to condensing)[3]	RES_RETAIL	All	0.33	0.13	0.00	0.80

Moderate Income Qualified - Heating System, Boiler, Propane[4]	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.[5]

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

Measure Code	RES-HVAC-FOP
Market	Residential
Program Type	Lost Opportunity, Retrofit
Category	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.
MMBtu = heating load MMBTUs * (1/AFUE base – 1/AFUEee)

Where:
Heating load Propane = 58.35[1]

Energy Savings for Primary Energy Impact [2]

Moderate Income Qualified - Heating System, Furnace, Oil
MMBtu = heating load MMBTUs * (1/AFUE base – 1/AFUEee)
Heating load Oil = 68.41 MMBTUs

Moderate Income Qualified - Heating System, Furnace, Other
MMBtu = heating load MMBTUs * (1/AFUE base – 1/AFUEee)
Heating load Propane = 58.35[1]

Measure Name	ΔMMBtu	ΔkWh	ΔkW
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.[4] 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. [5]

Measure Name	Core Initiative	PA	EUL[6]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [7]

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.[8]

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

Measure Code	RES-HVAC-FG
Market	Residential
Program Type	Retrofit
Category	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. [1]

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	ΔMMBtu	ΔkWh	Max Demand Factor	ΔkW
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,[2]

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 >= 95% (actual 95.2% AFUE) with an electronically commutated motor installed or AFUE >= 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. [3]

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 - Furnace, Non-Condensing to Condensing 95 AFUE	RES_RETAIL	All	17	n/a	n/a	17
Moderate Income Qualified - Furnace, Non-Condensing to Condensing 97 AFUE	RES_RETAIL	All	17	n/a	n/a	17
Moderate Income Qualified - Boiler, Non-Condensing to 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Furnace, Non-Condensing to Condensing 95 AFUE	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Furnace, Non-Condensing to Condensing 97 AFUE	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Boiler, Non-Condensing to Condensing 95 AFUE	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Moderate Income Qualified - Furnace, Non-Condensing to Condensing 95 AFUE	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.43
Moderate Income Qualified - Furnace, Non-Condensing to Condensing 97 AFUE	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.43
Moderate Income Qualified - Boiler, Non-Condensing to 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.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [5]

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

Measure Code	RES-HVAC-HP-C
Market	Residential
Program Type	Retrofit
Category	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 EA2C268 EA2c273 EA2c290 EA2c317 EA2c323 EA2c325 EA2c327
CVEO Heat Pumps, Propane	Residential Coordinated Delivery (RES_CD)	CVEO3	CLC	EA2c269 EA2c267 EA2c274 EA2c291 EA2c318 EA2c324 EA2c326 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1]

Impact Factors for Calculating Net Savings:

NTG rates are based on an evaluation study.[2]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[3]

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 (High Rise)	RES_CD	All	$5.98					
Custom Heat Pumps, Displacing Oil (High Rise)	RES_CD	All	$5.98					
Custom Heat Pumps, Displacing Propane (High 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

Measure Code	RES-HVAC-HPDCU
Market	Residential
Program Type	Operations and Maintenance
Category	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:[1]
$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$ = [Tons x 12kBtu/hr/Ton x (1/SEER) x $HOURS_C$ x 5%] + [Tons x 12kBtu/hr/Ton x (1/HSPF) X $HOURS_H$ x 5%]
$\Delta kWcool = \Delta kWh_{cool} \times$ Annual Maximum Demand Factor (cool)
$\Delta kWheat = \Delta kWh_{heat} \times$ 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
$Hours_C$ = Equivalent Full Load Hours (EFLH) for cooling
$Hours_H$ = EFLH for heating
5% = Average demand reduction of 5%[2]

Savings for Heat Pump Digital Check-up/Tune-Up:

Measure Name	Energy Type	Average Capacity (tons)[3]	SEER	HSPF	Hours[4]	ΔkWh	Annual Max Demand Factor[5]	ΔkW
Heat Pump Digital Check-Up/Tune-Up	Electric	3.03	13.0	7.7	419 (cool) 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.[6]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-HVAC-FS-DMSHP
Market	Residential
Program Type	Retrofit
Category	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.[1] Savings were calculated via simulation model runs assuming the existing heating system or zones will be fully displaced.[2]

Capacity for DMSHP Replacing Electric Heat = 2.0 Tons
Capacity of new Heat Pump for oil/propane = 3.9 Tons [3]

The same savings are used for moderate income and standard income projects.

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	3.75/ 7.49	2.32/ 4.64	1670/ 3340
DMSHP Fully Displacing Existing Boiler, Oil	17.8/ 69.3	-0.75 -2.92	-1982/ -7730
DMSHP Fully Displacing Existing Boiler, Propane	17.8/ 69.3	-0.75 -2.92	-1982/ -7730
DMSHP Fully Displacing Existing Boiler, Gas	17.8/ 69.3	-0.75 -2.92	-1982/ -7730

For Air to Water Heat Pump

Information on the savings analysis can be found here [4] [5] This is for all Air-to-water heat pump measures; oil, gas and propane.

Measure Name	ΔkWh	ΔkW	ΔMMBTU Fuel Savings
Air-to-Water Heat Pump 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. [6]

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 measures 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[7]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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	-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	-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	-0.02	0.65
Moderate Income Qualified - DMSHP displacing Electric Heat	RES_RETAIL	All	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	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	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	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	-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	-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	-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_P	SO_{NP}	NTG[8]
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

Measure Code	RES-HVAC-FSHP
Market	Residential
Program Type	Retrofit
Category	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.[1] Savings were calculated via simulation model runs assuming the existing heating system will be fully displaced.[2]

Capacity of new Heat Pump = 4.7 Tons [3]

Same savings are used for both standard and moderate income.

Measure Name	Saved MMBtu Oil/Propane/Gas Per Ton/Per Whole Home	ΔkW	ΔkWh
Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane	17.9/83.9	-0.87/ -4.09	-2132/ -10020
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	17.9/83.9	-0.87/ -4.09	-2132/ -10020
Central Ducted Heat Pump Fully Displacing Existing Furnace, Gas	17.9/83.9	-0.87/ -4.09	-2132/ -10020

For Ground Source Heat Pump

Information on the savings analysis can be found here [4] Gas savings are set equal to the propane savings.

Measure Name	ΔkWh	ΔkW	ΔMMBTU 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. [5]

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 look 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[6]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[7]	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-HVAC-FS-DMSHP-P
Market	Residential
Program Type	Retrofit
Category	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. [1] [2]

Capacity for DMSHP Replacing Electric Heat = 2.0 Tons
Capacity of Heat Pump for all other measure = 2.8 Tons [3]

Same gross savings will be claimed for both moderate income and standard income measures.

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 Displacing Existing Boiler, Oil	16.1/45.0	-0.51/ -1.42	-1505/ -4213
2022	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	17.4/48.7	-0.57/ -1.61	-1658/ -4642
2023	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	18.3/51.1	-0.61/ -1.71	-1743/ -4881
2024	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	19.1/ 53.6	-.065/ -1.81	-1828/ -5119
2022-2024	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Gas	16.1/45.0	-0.51/ -1.42	-1505/ -4213
2022-2024	DMSHP Integrated Controls Retrofit Oil	8.8/ 24.6	-0.26/ -0.71	-599/ -1678
2022-2024	DMSHP Integrated Controls Retrofit, Propane	9.01/ 25.2	-0.26/ -0.71	-599/ -1678
2022-2024	DMSHP Integrated Controls Retrofit, Gas	8.8/ 24.6	-0.26/ -0.71	-599/ -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. [4]

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[5]	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	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG[6]
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

Measure Code	RES-HVAC-FSHP-P
Market	Residential
Program Type	Retrofit
Category	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.[1] [2]

Capacity of new Heat Pump = 3.7 tons [3]
Gross savings are the same between the standard and moderate income measure offerings.

Year	Measure Name	Saved MMBtu Oil/Propane/Gas Per Ton/Per Whole Home	ΔkW Per Ton/Per Whole Home	ΔkWh Per Ton/Per Whole Home
2022-2024	Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	13.4/49.6	-0.47/-1.75	-1233/-4563
2022-2024	Central Ducted Heat Pump Partially Displacing Existing Furnace, Gas	13.4/49.6	-0.47/-1.75	-1233/-4563
2022	Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	15.1/56.0	-0.55/-2.03	-1408/-5210
2023	Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	17.3/64.1	-0.67/-2.49	-1700/-6290
2024	Central Ducted Heat Pump Partially 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. [4]

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.[5]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Central Ducted Heat Pump Partially 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG[6]
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)

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

Measure Description:

The verification of proper charge and airflow during installation of new Heat Pump systems.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
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:[1]

$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$ = [Tons x 12kBtu/hr/Ton x (1/SEER) x $HOURS_C$ x 5%] + [Tons x 12kBtu/hr/Ton x (1/HSPF) X $HOURS_H$ x 5%]
$\Delta kWcool = \Delta kWh_{cool} \times$ Annual Maximum Demand Factor (cool)
$\Delta kWheat = \Delta kWh_{heat} \times$ 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
$Hours_C$ = Equivalent Full Load Hours (EFLH) for cooling
$Hours_H$ = EFLH for heating
5% = Average demand reduction of 5%[2]

Savings for Heat Pump QIV:

Measure Name	Energy Type	Average Capacity (tons)[3]	Average SEER[4]	Average HSPF[5]	Hours[6]	ΔkWh	Annual Max Demand Factor[7]	ΔkW
Heat Pump QIV	Electric	3.03	17.6	9.81	419 (cool) 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.[8]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heat Pump 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	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[9]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-HVAC-HRV
Market	Residential
Program Type	Time of Sale
Category	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. [1] An electric penalty results due to the electricity consumed by the system fans.

Measure Name	ΔMMBtu/Unit	ΔkWh/Unit	ΔkW/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.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heat Recovery Ventilator	RES_RETAIL 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Recovery Ventilator	RES_RETAIL 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.[3]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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)

Measure Code	RES-HVAC-PW
Market	Residential
Program Type	Retrofit
Category	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.[1]

Measure Name	Δ 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-HVAC-PT
Market	Residential
Program Type	Retrofit
Category	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[1,2,3] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[4]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[5] For Attached Low Rise and High Rise the measure persistence was estimated to be 69%[6] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7] [8] 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.[9]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[10]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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					

Endnotes:

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

Measure Code	RES-HVAC-QIDM
Market	Residential
Program Type	Time of Sale
Category	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.[1]

Savings for Quality Installation with Duct Modification:

Measure Name	Energy Type	ΔkWh	ΔkW
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
QI 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.[3]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-PL-ROOMAC
Market	Residential
Program Type	Time of Sale
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	kWh	kW
Room Air Conditioner	36	0.05

Baseline Efficiency:

The baseline efficiency case is a unit meeting the current federal standard.[3]

High Efficiency:

The high efficiency case is an ENERGY STAR® qualified air conditioner.[4]

Measure Life:

The measure life is 12 years.[5]

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_E	RE_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

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.[7]

Impact Factors for Calculating Net Savings:

Net to gross factors based on evaluation results.[8]

2022

Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Conditioner	RES_RETAIL	All	0.42	0.00	0.00	0.56

2023

Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Conditioner	RES_RETAIL	All	0.46	0.00	0.00	0.54

2024

Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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
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

Measure Code	RES-WH-CWH
Market	Residential
Program Type	Retrofit
Category	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.[1]

Measure Name	Δ MMBtu	Δ kWh	Δ 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.[2]

ΔkWh = Average annual energy reduction per unit: -43.0 kWh
ΔkW = 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>= 0.80.

Measure Life:

The measure life is 15 years.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Net-to-gross is based on evaluation results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-WH-FA
Market	Residential
Program Type	Retrofit
Category	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.[1] [2] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3]

Measure Name	ΔkWh	ΔkW	Δ 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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5] [6] 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.[7]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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					

Endnotes:

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

Measure Code	RES-WH-HPWH
Market	Residential
Program Type	Time of Sale
Category	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 [1]

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	1799	0	-86.3	Gas = -0.50 Oil = -0.10 Propane = -0.07	1712	0.00025	0.43	Gas = 0.50 Oil = 0.10 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.[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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:[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-WH-IWH
Market	Residential
Program Type	Retrofit
Category	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.[1]

Measure Name	Δ 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. [2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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, 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

Measure Code	RES-WH-S
Market	Residential
Program Type	Retrofit
Category	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.[1] [2] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3]

Measure Name	ΔkWh	ΔkW	Δ 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.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead	RES_CD 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.[5]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6] [7] 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.[8]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[9]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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 (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

Measure Code	RES-WH-STV
Market	Residential
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW	Δ 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.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead with TSV	RES_CD 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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

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.[6]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[7] [8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-WH-ODTWH
Market	Residential
Program Type	Retrofit
Category	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[1] . 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	Δ kWh	Δ kW[2]	Δ 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.[3]

High Efficiency:

The high efficiency case is an On Demand tankless water heater with an UEF >= 0.87

Measure Life:

The measure life is 19 years for gas equipment[3] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[5]

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.[6] [7]

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)

Measure Code	RES-WH-PW
Market	Residential
Program Type	Retrofit
Category	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.[1] [2] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3]

Savings for Pipe Wrap (Water Heating):

Measure Name	ΔkWh	ΔkW	Δ 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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-S-HW
Market	Residential
Program Type	Retrofit, Time of Sale
Category	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:

ΔkWh = [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 days/year)*(0.000293071 kWh/BTU)*(V)*(ρ)*(Cp)*(ΔT)/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
ρ = Water density (lb/gallon) = 8.24
Cp = Specific heat of water (Btu/lb) = 1
ΔT = Difference between inlet and outlet temp (ΔT) = 67
UEF = Uniform Energy Factor (see table below)

Electric Storage Water Heater Conservation Standards[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-WH-SASWH
Market	Residential
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

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[3]. For the early retirement portion. the baseline efficiency is an existing 0.58[4] UEF standalone water heater.

High Efficiency:

The high efficiency case is a stand-alone storage water heater with an energy factor >= 0.66[4].

Measure Life:

The measure life is assumed to be 9 years.[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
All	Water Heater, Stand Alone Water Heater, Gas	RES_CD, 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.[6]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[7]

PA	Measure Name	Core Initiative	FR	SOP	SONP	NTG
All	Water Heater, Stand Alone 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 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

Measure Code	RES-WH-TV
Market	Residential
Program Type	Retrofit
Category	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.[1]

Measure Name	ΔkWh	ΔkW[2]	Δ 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.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Thermostatic Shut-off Valve	RES_CD 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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

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.[6]

Impact Factors for Calculating Net Savings:

Net to gross factors for High Rise based on evaluation results.[7] [8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-L-F
Market	Residential
Program Type	Retrofit
Category	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:
$\Delta kWh = Hours_{PRE} * ((QTY_{PRE} \times Watts_{PRE}) - (QTY_{EE} \times Watts_{EE})) / 1000$
$\Delta kW = \Delta kWh \times kW/kWh$

Where:
QTY_{PRE} = Quantity of pre-retrofit fixtures/bulbs
QTYEE = Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$ = Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$ = Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$ = 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[1]

Annual hours of use for Residential Coordinated Delivery are based on evaluation results.[2] [3] [4] Annual hours of use for Income Eligible in-unit fixtures are deemed based on the space type -- see table below.[5] 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.[9]

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); LED Fixture, Indoor Common Area (High Rise)	RES_CD	All	6	n/a	n/a	6
LED Fixture, Common Area, Linear (Attached Low Rise); 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); 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[11]

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.[12]

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.[13]

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.[16]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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_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

1.56. Lighting - Occupancy Sensors

Measure Code	RES-L-OS
Market	Residential
Program Type	Retrofit
Category	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:
ΔkWh = (WattsControlled * Hours * 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:
ΔkWh = ((HighWatts - LowWatts) * 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1]

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_P	SO_{NP}	NTG
Occupancy Sensor, Common Area (Attached Low Rise)	RES_CD	All	0.14			0.86
Occupancy Sensor, Common Area (High Rise)	RES_CD					
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

Measure Code	RES-L-LEDB
Market	Residential
Program Type	Lost Opportunity, New Construction, Retrofit
Category	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[1] and hours of use[2] [3] 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[4](see table below). For Income Eligible In-Unit Fixtures, vendors reference the 2014 Northeast HOU Study (see table below).[5] For Income Eligible common area measures, vendors calculate the hours based on site conditions.

Savings are then calculated per the algorithm below.
$\Delta kWh = ((QTY_{PRE} \times Watts_{PRE}) - (QTY_{EE} \times Watts_{EE}) \times Hours)/1000$
$\Delta kW = \Delta kWh \times kW/kWh$

Where:
QTYPRE = Quantity of pre-retrofit fixtures/bulbs
QTYEE = Quantity of efficient fixtures/bulbs installed
WattsPRE = Rated watts of pre-retrofit fixtures/bulbs
WattsEE = 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[6]

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) LED Bulb, Common Area (Residential End Use)	RES_CD 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) LED Bulb, Common Area (High Rise) LED Bulb, Common Area (Residential End Use)	RES_CD RES_CD CI_RETRO	All	3	n/a	n/a	1

LED Fixture, Indoor In Unit (Multifamily)	RES_CD	All	20	n/a	n/a	5
LED Fixture, Common Area (Attached Low Rise); LED Fixture, Indoor Common Area (High Rise)	RES_CD	All	6	n/a	n/a	6
LED Fixture, Common Area, Linear (Attached Low Rise); 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); 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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) LED Bulb, Common Area (Residential End Use)	RES_CD CI_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.[9] 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.[10]

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.[11]

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.[16]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
LED Bulb, Common Area (Attached Low Rise)	RES_CD	All	0.14			0.86
LED Bulb, Common Area (High Rise) LED Bulb, Common Area (Residential End Use)	RES_CD CI_RETRO	All	0.14			0.86
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 Unit		**per KWh**		**per Therm**
LED Bulb, Common Area (Attached Low Rise)	RES_CD	All	$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit.		$0.027			
LED Bulb, Common Area (High Rise) LED Bulb, Common Area (Residential End Use)	RES_CD CI_RETRO	All	$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit.		$0.027			
LED Fixture, Common Area (Attached Low Rise)	RES_CD	All	$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit.		$0.027			
LED Fixture, Common Area, Linear (Attached Low Rise)	RES_CD	All			$0.027			
LED Fixture, Common Area, Exterior (Attached Low Rise)	RES_CD	All			$0.027			
LED Fixture, Indoor Common Area (High Rise)	RES_CD	All	$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit.		$0.027			
LED Fixture, Linear Indoor Common Area (High Rise)	RES_CD	All	$26/Unit. Values are applied per fixture in the BC model, and adjusted for the number of fixtures/unit.		$0.027			
LED Fixture, Outdoor Common Area (High Rise)	RES_CD	All	$26/Unit. Values are applied per fixture in the BC model, and adjusted for 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 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

Measure Code	RES-MAD-PP
Market	Residential
Program Type	Retrofit
Category	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[1] :
$\Delta kWh = UEC_{baseline} - UEC_{efficient}$
$UEC_{annual} = UEC_{day} * days$
$UEC_{day} = (hours_{low} * P_{low} + hours_{high} * P_{high})/1000$

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 high 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.[2]

Measure Name	ΔkWh	ΔkW
Pool Pump	151	0.16

Baseline Efficiency:

The baseline efficiency case is pump that meets the July 2021 federal standard.[3]

High Efficiency:

The high efficiency case is an Energy Star rated pump.

Measure Life:

The measure life is 6 years.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net-to-gross factors are based on evaluation study results.[6]

2022

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pool Pump	RES_RETAIL	All	0.11	0.00	0.00	0.89

2023

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pool Pump	RES_RETAIL	All	0.13	0.00	0.00	0.87

2024

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-MAD-VFD
Market	Residential
Program Type	Retrofit
Category	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 / HPSP = 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_{SP})	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_{WP})	Multi-Family	0.109	-0.006	0.194	0.221	0.221	0.109	0.274	0.265	0.297

kW / HP_{WP} = 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[1] [2] (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 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 lifetime is 15 years.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-CM-CSA
Market	Residential
Program Type	Lost Opportunity, New Construction
Category	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.[1] 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

Measure Code	RES-HVAC-ELEC
Market	Residential
Program Type	Lost Opportunity
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	Core Initiative	ΔkWh	ΔkW
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.[3]

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)[4]
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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-PL-APS
Market	Residential
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3] [4] For Retail In-service rates are based on consumer surveys, as found in the referenced study.[5]

Realization Rates

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[6]

Coincidence Factors

Summer and winter coincidence factors are from the referenced study.[7]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on study results.[8] 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

Measure Code	RES-R-VM
Market	Residential
Program Type	Retrofit
Category	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:

ΔkWh = (kWRATED)(Hours)(SAVE)
ΔkW = ΔkWh / Hours

Where:
kWrated = 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[1]

Equipment Type	kWRATED	SAVE (%)	ΔkW	ΔkWh
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	RES-BE-RNC
Market	Residential
Program Type	New Construction
Category	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.[1]
The Multifamily High-Rise baseline is evaluated separately.[2]
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]
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.[5] [6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[7] 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:

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

Measure Code	IE-PL-ERDH
Market	Income Eligible
Program Type	Retrofit
Category	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:
ΔkWh = Dehumidification Load * ((1/EffRETIRE)-(1/EffEE))

Where:
Dehumidification Load = Typical annual moisture removal, in Liters/year. Average annual dehumidifictaion load is 1,520 Liters/year.[1]
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.[2]

Measure Name	ΔkWh	ΔkW
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.[3]

High Efficiency:

The high efficiency case is a new ENERGY STAR® unit.[4]

Measure Life:

The measure life is 12 years.[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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_Specification_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

Measure Code	IE-A-ERCW
Market	Income Eligible
Program Type	Retrofit
Category	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:

ΔkWh = [(Capacity x 1/IMEFbase x Ncycles) * (%CWkwhbase + %DHWkwhbase + %Dryerkwhbase)]
- [(Capacity x 1/IMEFeff x Ncycles) x (%CWkwheff + %DHWkwheff + %Dryerkwheff)]
ΔMMBTUs = [(Capacity x 1/MEFbase x Ncycles) x ((%DHWffbase x r_eff) + %Dryerffbase]
- [(Capacity x 1/MEFeff x Ncycles) x (%DHWffeff x r_eff) + %Dryergaseff]xMMBTU_convert

Where:
Capacity = washer volume in ft3. Existing top loading washer is 3.09 ft3, new standard efficiency top loading washer is 3.38 ft3, ENERGY STAR front loading is 3.90 ft
IMEF = Integrated Modified Energy Factor and is measured in ft3 /kWh/cycle

Ncycles = 283 loads per year[1]

%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[2]

	% 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[3]	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^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^3

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.[4]

Measure Life:

The effective useful life of the new clothes washer is assumed to be 12 years.[5] 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:
ΔWater (gallons) = (Capacity * (IWFbase - IWFeff)) * Ncycles
Total water savings are 4,777 gallons.

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

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_P	SO_{NP}	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
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

Measure Code	IE-A-FR
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	Core Initiative	ΔkWh	ΔkW
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-A-RR-MF
Market	Income Eligible
Program Type	Retrofit
Category	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 orfreezer. 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 kWhES by 0.9 (i.e., the Energy Star units are assumed to be 10% more efficient than the kWhstd units). The default value is 398 kWh.
kWhused = Average annual consumption of used equipment. Default value is 475 kWh.[1]
RUL = Remaining Useful life assumed to be 6 years
EUL = Estimated useful life for a new refrigerator is 12 years.[2]
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
ΔkWh = 330, using the default assumptions

kW/kWh = Average kW reduction per kWh reduction: 0.00018 kW/kWh[3]
ΔkW = 0.06, using the default assumptions

Occupant Adjustment Factor[4]

Number of Occupants	Focc
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.[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[7]

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

Measure Code	IE-A-RR-SF
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure	ΔkWh	ΔkW
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-A-AR
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-A-BEM
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-BS-AS-MF
Market	Income Eligible
Program Type	Retrofit
Category	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:

MMBtu = (Vol x ΔACH x 0.018 x HDD60 x 24) / (1,000,000 * ηheating)
kWh = MMBtu * 293.1
kW = kWh x kW/kWh

Where:
Vol = [ft3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
ΔACH = [ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)
HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below.
ηheating = [AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)
24 = Conversion factor: 24 hours per day
0.018 = [Btu/ft3- ºF] Air heat capacity: The specific heat of air (0.24 Btu/ºF.lb) times the density of air (0.075 lb/ft3)
1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu
293.1 = Conversion factor: 293.1 kWh/MMBtu
kW/kWh = Average kW reduction per kWh reduction: 0.00073 kW/kWh[1]

Hours:
Heating hours are characterized by the heating degree days for the facility.[2] 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
Worchester 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. 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 [3] .

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.[4]

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

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.[6]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[7]

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

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 : 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

Measure Code	IE-BS-I
Market	Income Eligible
Program Type	Retrofit
Category	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[1] :

Measure	kW/kWh Factor
Insulation (Electric)	0.00073
Insulation (Gas, Oil, Other FF)	0.00076

All PAs except Eversource:

$MMBtu = ((1/R_{exist} - 1/R_{new})*HDD * 24 * Area) / (1000000 * \eta_{heat})$
$kWh = MMBtu * 293.1$
$kW = kWh * kW/kWh_{heat}$

Where:
R_{exist} = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft2-°F/Btuh
R_{new} = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft2-°F/Btuh
Area = Square footage of insulated area
η_{heat} = Efficiency of the heating system (AFUE or COP)
293.1 = Conversion constant (1MMBtu = 293.1 kWh)
24 = Conversion for hours per day
HDD = Heating Degree Days; dependent on location, see table below
1,000,000 = Conversion from Btu to MMBtu
kW/kWh_{heat} = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

If Facility has central cooling then also calculate air conditioning savings:
$kWh_{cool} = ((1/R_{exist} - 1/R_{new}) * CDH * DUA * Area) / (1000 Btu/kBtu * \eta_{cool})$
$kW = kWh * kW/kWh_{cool}$

Where:
R_{exist} = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft2-°F/Btuh
R_{new} = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft2-°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[2]
Area = Square footage of insulated area
η_{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_{cool} = Average annual kW reduction per kWh reduction: 0.00073 kW/kWh

Hours:
Heating hours are characterized by the heating degree days for the facility.[3] 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
Worchester 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. 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).[4]

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[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [6]

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.[7]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[8]

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

Measure Code	IE-BS-W
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2] 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.[3] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[5]

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 (Multi Family)	IE_CD	CLC	$771.73		Varies by PA	$0.01		
Weatherization, Oil (Multi Family)	IE_CD	CLC	$771.73		Varies by PA	$0.01		
Weatherization, Other (Multi Family)	IE_CD	CLC	$771.73		Varies 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

Measure Code	IE-CM-CMIE
Market	Income Eligible
Program Type	Retrofit
Category	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[1]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[2]

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_P	SO_{NP}	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.[3]Custom - HVAC NEI values for Multifamily are based on 2021 results.[4]

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

Measure Code	IE-HVAC-BSC
Market	Income Eligible
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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.[3]

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

Measure Code	IE-HVAC-BR
Market	Income Eligible
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	IE-HVAC-CVEO-BAT
Market	Income Eligible
Program Type	Active Demand Response
Category	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.[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.[3] [4]

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.[5] [6]

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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.

Endnotes:

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

Measure Code	IE-HVAC-CVEO-SOLPV
Market	Income Eligible
Program Type	Early Replacement
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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[1].

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

Measure Code	IE-HVAC-WT
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] [2] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3] 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	ΔkWh	ΔkW	Δ 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) (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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-HVAC-DI
Market	Income Eligible
Program Type	Retrofit
Category	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[1]:

Measure Name	ΔkWh	ΔkW[2]	Δ 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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-HVAC-DI-MF
Market	Income Eligible
Program Type	Retrofit
Category	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:
ΔMMBtu = MMBtu x Units

Where:
Unit = Number of square feet of ductwork treated
MMBtu = Average annual MMBtu savings per unit: 0.035[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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, Oil (Multifamily)	IE_CD	All						
Duct Insulation, Other (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

Measure Code	IE-HVAC-DSAF-MF
Market	Income Eligible
Program Type	Retrofit
Category	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:

MMBtu = Annual Heating Consumption x % SAVE x 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[1]
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-HVAC-DSAF
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] [2]

Measure Name	ΔkWh	ΔkW[3]	Δ 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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-HVAC-FR
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Electric savings can be attributed to reduced fan run time.

Measure Name	Energy Type	MMBtu/unit	kWh/Unit	kW/Unit[2]
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-HVAC-HP-C
Market	Income Eligible
Program Type	Retrofit
Category	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 EB1a273 EB1a271 EB1a286 EB1a281 EB1b284
CVEO Heat Pumps, Propane	Income Eligible Coordinated Delivery (IE_CD)	CVEO1	CLC	EB1a268 EB1a272 EB1a270 EB1a287 EB1a282 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1] 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_P	SO_{NP}	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.[2]

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

Measure Code	IE-HVAC-FS-DMSDEH
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Savings were calculated via simulation model runs assuming a full displacement of the areas of the home being displaced by the heat pump.[2]

Capacity of new Heat Pump = 2.0 Tons[3]

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/ 5.13	2316/ 4631

Baseline Efficiency:

For displacement of electric heat, the equivalent HSPF for electric resistance heat is assumed to be 3.41 COP.[9]

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.[10]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[11]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-HVAC-FS-DMSHP
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Savings were calculated via simulation model runs assuming the existing heating system will be fully displaced.[2]

Capacity of new Heat Pump = 3.9 tons [3]

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 Fully Displacing Existing Boiler, Oil	17.78/ 69.33	-0.56 -2.19	-1508/ -5882
DMSHP Fully Displacing Existing Boiler, Propane	17.78/ 69.33	-0.56 -2.19	-1508/ -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[4]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG[5]
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

Measure Code	IE-HVAC-FSHP
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Savings were calculated via simulation model runs assuming the existing heating system will be fully displaced. [2]

Capacity of new Heat Pump = 4.7 tons [3]

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/ 83.91	-0.75/ -3.53	-1795/ -8437
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	17.85/ 83.91	-0.75/ -3.53	-1795/ -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. [3]

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[4]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	IE-HVAC-FS-DMSHP-P
Market	Income Eligible
Program Type	Retrofit
Category	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. [1] [2]

Capacity of new Heat Pump = 2.8 Tons [3]

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/ 44.3	-0.32/ -0.89	-994/ -2784

	Displacing Existing Boiler, Oil			
2022	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	17.18/ 48.1	-0.37/ -1.04	-1122/ -3141
2023	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	18.1/ 50.6	-0.40/ -1.13	-1193/ -3340
2024	DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	19.0/ 53.1	-.043/ -1.21	-1264/ -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[4]	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_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	IE-HVAC-FSHP-P
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] [2]

Capacity of new Heat Pump = 3.7 tons Tons[3]

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/ -1.34	-900/ -3328

2022	Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	14.5/53.8	-0.43/ -1.57	-1047/ -3873
2023	Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	16.9/62.5	-0.53/ -1.96	-1292/ -4781
2024	Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	17.85/66.1	-0.57/ -2.12	-1390/ -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. [4]

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[5]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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:

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

Measure Code	IE-HVAC-HS
Market	Income Eligible
Program Type	Retrofit
Category	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:

$\Delta MMBtu = Btu/hr \times (1/AFUE_{BASE} - 1/AFUE_{EE}) \times EFLH_{heat} \times (1/1000000)$

Where:
Btu/hr = Nominal heating capacity of the installed equipment (Btu/hr)
$AFUE_{BASE}$ = Average fuel utilization efficiency of the existing equipment (%)
$AFUE_{EE}$ = Average fuel utilization efficiency of the efficient equipment (%)
$EFLH_{Heat}$ = Equivalent full load heating hours for the facility (Hr)
1/1,000,000 = Conversion from Btu to MMBtu

Baseline Efficiency:

The baseline efficiency case is the existing inefficient heating system.

High Efficiency:

The high efficiency case is characterized by the rated efficiency ($AFUE_{EE}$) 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[1]	n/a	n/a	20
Heating System Retrofit, Furnace	IE_CD	All	18[2]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Coincidence Factors:

There are no electric savings for this measure.

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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)

Measure Code	IE-HVAC-PW
Market	Income Eligible
Program Type	Retrofit
Category	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.[1]

Measure Name	Δ 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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), 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

Measure Code	IE-HVAC-PT
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] [2] [3] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[4]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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)

Measure Code	IE-HVAC-WACR
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

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:
ΔkWh = (Capacityexisting /EERexisting – Capacitynew/EERnew) * hours/1000
ΔkW = (Capacityexisitng/EERexisting – Capacitynew/EERnew) /1000

Where:
Capacityexisitng = size of existing unit in BTUs/hour
Capacitynew = size of new unit in BTUs/hour
EERexisitng = Energy Efficiency Ratio of base AC equipment
EERnew = Energy Efficiency Ratio of new efficient AC equipment
Hours = Equivalent full load hours= 200 [3]

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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-WH-FA
Market	Income Eligible
Program Type	Retrofit
Category	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[1] and multifamily[2] evaluation study results. Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3]

Measure Name	ΔkWh	ΔkW	Δ 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.[4]

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.[5]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[7]

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

Measure Code	IE-WH-HPWH
Market	Income Eligible
Program Type	Time of Sale
Category	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.[1] For multifamily, savings are custom calculated.

	Water Heating Savings		Heating Savings (Penalty)		Total Savings			
Measure Name	**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 Oil = -0.10 Propane = -0.07	1712	0.00025	0.43	Gas = 0.50 Oil = 0.10 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.[2]

Measure Life:

The measure life is 13 years.[3]

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_E	RR_{NE}	RR_SP	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-WH-S
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] [2] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[3]

Measure Name	ΔkWh	ΔkW	Δ 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.[4]

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[5] per unit and multifamily are 1,759 gallons[6] per unit.

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-WH-STV
Market	Income Eligible
Program Type	Retrofit
Category	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 (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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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)

Measure Code	IE-WH-PW
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW	Δ 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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

PA	Measure Name	Core Initiative	FR	SO_P	SO_{NP}	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

Measure Code	IE-S-HW
Market	Income Eligible
Program Type	Early Replacement
Category	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:

ΔkWh = [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 days/year)*(0.000293071 kWh/BTU)*(V)*(ρ)*(Cp)*(ΔT)/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
ρ = Water density (lb/gallon) = 8.24
Cp = Specific heat of water (Btu/lb) = 1
ΔT = Difference between inlet and outlet temp (ΔT) = 67
UEF = Uniform Energy Factor (see table below)

Electric Storage Water Heater Conservation Standards[1]
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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_P	SO_{NP}	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

Measure Code	IE-WH-TV
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

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.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-WH-WHS
Market	Income Eligible
Program Type	Retrofit
Category	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:

$MMBtu = Units \times 18MMBtu/unit \times (1/EF_{BASE}) - (1/EF_{EE})$

Where:
Unit = Total number of dwelling units utilizing the water heater
18 MMBtu/Unit = Average annual water heating energy demand per dwelling unit [1]
EF_{BASE} = Energy Factor for the baseline water heater
EF_{EE} = Energy Factor for the new efficient water heater

Baseline Efficiency:

The baseline efficiency case is a stand-alone tank water heater is an existing 0.58 UEF standalone water heater.[2]

High Efficiency:

The high efficiency case is a stand-alone storage water heater with an energy factor >= 0.66.[3]

Measure Life:

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Indirect Water Heater	IE_CD	All	20[2]	n/a	n/a	20
Stand Alone Water Heater	IE_CD	All	13[3]	n/a	n/a	13
On Demand/Tankless Water Heater	IE_CD	All	20[4]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [5]

Coincidence Factors:

There are no electric savings for this measure.

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-L-LEDB
Market	Income Eligible
Program Type	Lost Opportunity, New Construction, Retrofit
Category	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[1] and hours of use[2] [3] 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[4](see table below). For Income Eligible In-Unit Fixtures, vendors reference the 2014 Northeast HOU Study (see table below).[5] For Income Eligible common area measures, vendors calculate the hours based on site conditions.

Savings are then calculated per the algorithm below.
$\Delta kWh = ((QTY_{PRE} \times Watts_{PRE}) - (QTY_{EE} \times Watts_{EE}) \times Hours)/1000$
$\Delta kW = \Delta kWh \times kW/kWh$

Where:
QTYPRE = Quantity of pre-retrofit fixtures/bulbs
QTYEE = Quantity of efficient fixtures/bulbs installed
WattsPRE = Rated watts of pre-retrofit fixtures/bulbs
WattsEE = 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[6]

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) LED Bulb (Multi Family)	IE_CD IE_CD	All	15	n/a	n/a	1
LED Bulb, Reflector (Single Family) LED Bulb, Reflector (Multi Family)	IE_CD IE_CD	All	15	n/a	n/a	1
LED Bulb, Specialty (Single Family) LED Bulb, Specialty (Multi Family)	IE_CD IE_CD	All	15	n/a	n/a	1
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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Bulb (Single Family) LED Bulb (Specialty) (Single Family) LED Bulb (Reflectors) (Single Family) LED Bulb (Multifamily) LED Bulb (Specialty) (Multifamily) LED Bulb (Reflectors) (Multifamily)	IE_CD	All	1.00	1.01	1.00	1.20	0.93	0.55	0.85
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.[9] 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.[10]

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.[11]

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.[16]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
LED Bulb (Single Family) LED Bulb (Multifamily) LED Bulb (Specialty) (Single Family) LED Bulb (Specialty) (Multifamily) LED Bulb (Reflectors) (Single Family) LED Bulb (Reflectors) (Multifamily) LED Bulb, Common Area (Multifamily)	IE_CD	All	0.0	0.0	0.0	1.0
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) LED Bulb (Multifamily) LED Bulb (Specialty) (Single Family) LED Bulb (Specialty) (Multifamily) LED Bulb (Reflectors) (Single Family) 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_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 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

Measure Code	IE-L-F
Market	Income Eligible
Program Type	Retrofit
Category	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:
$\Delta kWh = Hours_{PRE} * ((QTY_{PRE} \times Watts_{PRE}) - (QTY_{EE} \times Watts_{EE})) / 1000$
$\Delta kW = \Delta kWh \times kW/kWh$

Where:
QTY_{PRE} = Quantity of pre-retrofit fixtures/bulbs
QTYEE = Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$ = Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$ = Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$ = 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[1]

Annual hours of use for Residential Coordinated Delivery are based on evaluation results.[2] [3] [4] Annual hours of use for Income Eligible in-unit fixtures are deemed based on the space type -- see table below.[5] 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.[9]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[11]

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.[12]

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.[13]

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.[16]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	IE-L-OS
Market	Income Eligible
Program Type	Retrofit
Category	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:
ΔkWh = (WattsControlled * Hours * 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:
ΔkWh = ((HighWatts - LowWatts) * 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1]

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_P	SO_{NP}	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

Measure Code	IE-MAD-VFD
Market	Income Eligible
Program Type	Retrofit
Category	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_{SP} = Summer demand reduction based on building and equipment type. See table below.
kW / HP_{WP} = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

Savings Factors for C&I VFDs (kWh/HP[1] and kW/HP[2])

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_{SP})	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_{WP})	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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	IE-PL-APS
Market	Income Eligible
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

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_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3] [4]

Realization Rates

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[5]

Coincidence Factors

Summer and winter coincidence factors are based on referenced study.[6]

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

Measure Code	IE-R-VM
Market	Income Eligible
Program Type	Retrofit
Category	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:

ΔkWh = (kWRATED)(Hours)(SAVE)
ΔkW = ΔkWh / Hours

Where:
kWrated = Rated kW of connected equipment. Seefor 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[1]

Equipment Type	kWRATED	SAVE (%)	ΔkW	ΔkWh
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	COM-A-RFR
Market	Commercial
Program Type	Direct Install, Early Replacement, Early Retirement, Recycling, Retrofit
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[6]

Impact Factors for Calculating Net Savings:

All PAs use Statewide prescriptive net-to-gross results.[1]

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	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

Measure Code	COM-PL-RAP
Market	Commercial
Program Type	Time of Sale
Category	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/$Watt_{dust}$.

High Efficiency:

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

Measure Life:

The measure life is 3 years.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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

Measure Code	COM-BS-BOC
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-BS-ASREU
Market	Commercial
Program Type	Retrofit
Category	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:

kWh = (Vol x ACH x 0.018 x HDD x 24/nheating) / 3,413
MMBtu = (Vol x ACH x 0.018 x HDD x 24/nheating) / 1,000,000
kW = kWh x kW/kWh

Where:
Vol = [ft3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
ΔACH = [ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)
HDD60 = Heating degree-days, base 60 from TMY3 weather data. See table below. ηheating = [AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)
24 = Conversion factor: 24 hours per day

0.018 = [Btu/ft3- ºF] Air heat capacity: The specific heat of air (0.24 Btu/ºF.lb) times the density of air (0.075 lb/ft3)
1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu
3413 = Conversion factor: 3413 Btu/kWh
kW/kWh = Average kW reduction per kWh reduction: 0.00073 kW/kWh[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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

Measure Code	COM-BS-IREU
Market	Commercial
Program Type	Retrofit
Category	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:

$MMBtuannual = ((1/R_{exist} - 1/R_{new})*HDD * 24 * Area)/(1000000 * \eta_{heat})$
$kWh_{annual} = MMBtu_{annual} * 293.1$
$kW = kWh_{annual} * kW/kWh_{heating}$

Where:
R_{exist} = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft2-°F/Btuh
R_{new} = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft2-°F/Btuh
Area = Square footage of insulated area
η_{heat} = Efficiency of the heating system (AFUE or COP)
293.1 = Conversion constant (1MMBtu = 293.1 kWh)
24 = Conversion for hours per day

HDD = Heating Degree Days; dependent on location, see table below
1,000,000 = Conversion from Btu to MMBtu
kW/kWh heating = Average annual kW reduction per kWh reduction.[1]

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 (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).[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.4

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.5

Impact Factors for Calculating Net Savings:

Net to gross factors based on evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-CA-AN
Market	Commercial
Program Type	New Construction
Category	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:

Delta_kW = Delta_kWh / hr
Delta_kWh = (FLOW_base - FLOW_eng) x kW_SCFM x USE x 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.[1]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[2]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-CA-HEAC
Market	Commercial
Program Type	New Construction
Category	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 (CI_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. [1]
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Coincidence Factors:

CFs from the prospective results of the 2015 study of prescriptive compressed air.4

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross values based on the 2021 C&I Omnibus NTG Study[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-CA-LPDF
Market	Commercial
Program Type	New Construction
Category	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:

ΔkWh = [(HPcomp) x (0.7457) / eff] x [((Existing P) - (Adjusted P)) / (2x100)] x (Hours)
ΔkW = [(HPcomp) x (0.7457) / eff] x [((Existing P) - (Adjusted P)) / (2x100)]

Where:
ΔkWh = Energy savings
ΔkW = 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_LPDF_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.[1]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[2]
- Eversource, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[3]

Coincidence Factors:

- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations[4]
- 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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-CA-RAD
Market	Commercial
Program Type	New Construction
Category	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_{DRYER} = Full flow rated capacity of the refrigerated air dryer in cubic feet per minute (CFM). Obtain from equipment's Compressed Air Gas Institute Datasheet.
Save = Refrigerated air dryer kW reduction per dryer full flow rated CFM: 0.00554.[1]
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Coincidence Factors:

CFs from the prospective results of the 2015 study of prescriptive compressed air.[4]

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross values based on study results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-CA-ZLCD
Market	Commercial
Program Type	New Construction
Category	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:

ΔkWh = (Quantity) x (CFMpipe) x (CFMsave) x (Save) x (Hours)
ΔkW = (Quantity) x (CFMpipe) x (CFMsave) x (Save)

Where:
ΔkWh = Energy savings
ΔkW = Demand savings
CFMpipe = CFM capacity of piping. Site specific.
CFMsaved = Average CFM saved per CFM of piping capacity: 0.049
Save = Average savings per CFM: 0.210 kW/CFM[1]
Hours = Annual operating hours of the zero loss condensate drain

Baseline Efficiency:

The baseline efficiency case is installation of a standard condensate drain on a compressor system.

High Efficiency:

The high efficiency case is installation of a zero loss condensate drain on a single operating compressor rated ≤ 75 HP.

Measure Life:

This measure has been determined to be an add on single baseline measure for retrofit installations.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Compressed Air - Zero Loss Condensate Drains	CI_NB&MR, 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Compressed Air - Zero Loss Condensate Drains	CI_NB&MR, CI_EQUIP, CI_RETRO	National Grid, Unitil	1.00	1.00	1.00	1.00	1.00	0.80	0.54
Compressed Air - Zero Loss Condensate Drains	CI_NB&MR, CI_EQUIP, 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 Rates3 :

• National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[4]
• Eversource, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations.[5]

Coincidence Factors:

- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations.[6]
- 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.[7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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_LPDF_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

Measure Code	COM-CM-CMREU
Market	Commercial
Program Type	Retrofit
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 (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 - 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.[1]
- CHP - Custom: RRs based on evaluation of PY 2012 projects.[2] Unitil uses statewide results given their small sample size. Note that RR_{NE} applies to project fossil fuel penalty.
- Remaining realization rates are based on multifamily impact evaluation study.[3]

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.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Non-Lighting - Custom (Residential End Use)	CI_RETRO	All	0.046	0.013	0.053	1.02
Lighting - Custom (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.[5]

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

Measure Code	COM-CM-CMTRN
Market	Commercial
Program Type	Retrofit
Category	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 - Retrocomissioning (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[1] 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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, 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 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.3 All PAs use electric non-lighting results from the 2020 small business impact study, which included samples of both custom and prescriptive.4

•Gas RRs: Eversource, National Grid, and EGMAuse PA specific results based on evaluation of PY2018 projects, while other PAs use statewide average.5

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.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[7].

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 Steam, Gas , <=1.5" (Turnkey)	CI_RETRO	All	n/a	n/a	$ -	n/a	$ 0.863	n/a
Pipe Wrap Steam, Gas , 3" (Turnkey)	CI_RETRO	All	n/a	n/a	$ -	n/a	$ 0.863	n/a
Boiler Reset Control (Turnkey)	CI_RETRO	All	n/a	n/a	$ -	n/a	$ 0.863	n/a
Lighting Controls - Interior (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.127	n/a	$ -	n/a
Lighting Controls - Exterior (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.127	n/a	$ -	n/a
Compressed Air - Custom (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.018	n/a	$ -	n/a
Motors & VFD - Custom (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.018	n/a	$ -	n/a
VFD - Prescriptive (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.002	n/a	$ -	n/a
VFD with Motor - Prescriptive (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.002	n/a	$ -	n/a
Retrocomissioning (Turnkey)	CI_RETRO	All	n/a	n/a	$ 0.283	n/a	$ -	n/a
Retrocomissioning (Turnkey)	CI_RETRO	All	n/a	n/a	$ -	n/a	$ 1.439	n/a
Retrocomissioning, Gas - Custom (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

Measure Code	COM-CM-CMLCI
Market	Commercial
Program Type	Custom
Category	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
Retrocomissioning, 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[1] 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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	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[4] . Unitil uses statewide results given their small sample size. Note that RR_{NE} 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[5] ; electric RRs based on 2021 analysis[6.] 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.[7]
- Gas (all): RRs based on evaluation of PY2018 projects.[8]

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.[8]

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.[10]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[NMR, 2021. C&I O&M and non-O&M NEI Study.11]

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

Measure Code	COM-HVAC-ELEC
Market	Commercial
Program Type	Lost Opportunity
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	Core Initiative	ΔkWh	ΔkW
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.[3]

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)[4]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-BE-ADR
Market	Commercial
Program Type	Active Demand Response
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

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.[6]

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.[7]
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_P	SO_{NP}	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

Measure Code	COM-FSE-CB
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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.[1]

Energy Savings for Conveyor Broiler

Conveyor Size	ΔkWh	Δtherms
<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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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 WPSCGNRCC171226A11, 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

Measure Code	COM-CE-CF
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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:
ΔkWh = ΔkWh
ΔkW = ΔkW / Hours
Where:
ΔkWh = gross annual kWh savings from the measure per table below
ΔkW = gross average kW savings from the measure per table below
Hours = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Fryer [1]

Equipment Type	ΔkW	ΔkWh
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[2]

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.[3]

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 [4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[5]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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 August 27, 2021
2: https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_serviceAugust 27, 2021
3: MA appliance standards (003)
4: 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

Measure Code	COM-FSE-CEG
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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[1]

Measure Name	kWh	kW
Commercial Electric Griddle	3,965	0.90

delkWh = SAVE x Width x Hours
delkW = SAVE x Width

Where:
ΔkWh = gross annual kWh savings from the measure. With default Width, average savings are 3,965 kWh.
ΔkW = 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	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:

1: https://www.energystar.gov/partner_resources/energy_star_training_center/commercial_food_serviceAugust 27, 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

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

Measure Code	COM-FSE-CEO
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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:
$\Delta kWh = kWh$
$\Delta kW = KWh / hours$

Where:
ΔkWh = gross annual kWh savings from the measure. See table below.
ΔkW = gross average kW savings from the measure. See table below.
Hours = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Ovens[1]

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.[2] [3]

The baseline efficiency case is a convection oven with a cooking energy efficiency of 68% and idle energy rate of 1.8 kW.[4] [5]

The baseline efficiencies represents the mid-point between the new Massachusetts Appliance Standard[6] minimum threshold (50%) and the current year baseline efficiency (35%).

High Efficiency:

Qualifying models muse 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.[7]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[8]

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[9]

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 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; 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; August 27, 2021
6 : Appliance Standard.pdf
7 : 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

Measure Code	COM-FSE-CESC
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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:[1]

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. [2] [3]

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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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

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; August 27, 2021
4: 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

Measure Code	COM-FSE-FHC
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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:

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 = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Hot Food Holding Cabinets[1]

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%)[2]

The baseline efficiency idle rate is as follows:

Equipment Type	kW idle rate
Full Size - Tier 1	$\leq$ 0.65
3/4 Size - Tier 1	$\leq$ 0.51
1/2 Size - Tier 1	$\leq$ 0.31
Full Size - Tier 2	$\leq$ 0.65
3/4 Size - Tier 2	$\leq$ 0.51
1/2 Size Tier 2	$\leq$ 0.31

High Efficiency:

The high efficiency idle energy rate for HFHC is as follows:

Equipment Type	kW idle rate
Full Size - Tier 1	$\leq$ 0.30
3/4 Size - Tier 1	$\leq$ 0.29
1/2 Size - Tier 1	$\leq$ 0.2
Full Size - Tier 2	$\leq$ 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Food Holding Cabinet	CI_NB&MR 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.[3]

Measure	Initiative	PA	FR	SO_P	SO_{NP}	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. [4]

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
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 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

Measure Code	COM-FSE-CF
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [3]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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:

1: 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
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

Measure Code	COM-FSE-CG
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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 <= 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.[1]

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 <= 2,650 Btu/h per square foot of cooking surface utilizing ASTM Standard F1275.

Measure Life:

The measure life is 12 years.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [3]

Measure	Initiative	PA	FR	SO_P	SO_{np}	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.[4]

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
2: 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

Measure Code	COM-FS-CO
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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.[1]

Savings for the Conveyor Oven are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator:[2]

Measure Name	ΔMMBtu
Convection Oven, Tier 1 Convection Oven, Tier 2	15.6 33.8
Combination Oven, Tier 1 Combination Oven, Tier 2	14.8 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 Convection Mode: 54% Cooking Efficiency; 9,607 Btu/hr idle rate
Conveyer 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 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 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.[3] [4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [5]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [6]

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
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
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

Measure Code	COM-FSE-CS
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [3]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [4]

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:

1: 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

Measure Code	COM-FS-UFB
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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. [1]
Savings = $\text{Energy Consumption}_{Base}$ - $\text{Energy Consumption}_{Eff}$

Where:
$\text{Energy Consumption}_{Base}$ = [IER_{Base} X OHD_{Base} X OHY_{Base}] / 100,000
$\text{Energy Consumption}_{Eff}$ = [IER_{Eff} X OHD_{Eff} X OHY_{Eff}] / 100,000

IER_{Base} = 25,000 (Btuh) (Broiler Idle Energy Rate)
IER_{Eff} = 20,000 (Btuh) (Broiler Idle Energy Rate)
OHD_{Base} = 12 (Operating Hours/Day in the Baseline Case)
OHD_{Eff} = 12 (Operating Hours/Day in the Efficient Case)
OHY_{Base} = 363 (Operating Hours/Year in the Baseline Case)
OHY_{Eff} = 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 <= 22 kBtu/hr/ln-ft at 600 degrees F and an idle and cooking energy rate <=20,000 Btu/hr with a production capacity of 20 lb/hr.

Measure Life:

The measure life is 12 years.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [3]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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

Measure Code	COM-FSE-HTCD
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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:

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 High Temperature Commercial Dishwashers:[1]

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[2]:

Dishwasher Type	Gallons per Rack	Idle Energy Rate (kW) Tier 1	Idle Energy Rate (kW) Tier 2
Under Counter	$\leq$ 0.98	$\leq$ 0.63	$\leq$ 0.63
Door Type	$\leq$ 1.09	$\leq$ 0.79	$\leq$ 0.79
Single Tank Conveyor	$\leq$ 0.79	$\leq$ 1.72	$\leq$ 1.72
Multi Tank Conveyor	$\leq$ 0.76	$\leq$ 2.42	$\leq$ 2.42
Pot, Pan, and Utensil	$\leq$ 0.64	$\leq$ 1.2	$\leq$ 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%)[3] .

High Efficiency:

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR® Efficiency Requirements as follows[4]:

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:[5]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[5]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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[6] .

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 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 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 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 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

Measure Code	COM-FSE-CIM
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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.
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 Commercial Ice Machine:[1]

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.[2]

Measure Life:

The measure life for a new ice making machine is assumed to be 8 years.[3]

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.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	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[6] .

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 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 June 29, 2021
3 : 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 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

Measure Code	COM-FSE-LTCD
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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:[1]

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	$\leq$ 1.46	$\leq$ 1.46	$\leq$ 0.50
Door Type	$\leq$ 1.64	$\leq$ 1.64	$\leq$ 0.60
Single Tank Conveyor	$\leq$ 1.05	$\leq$ 1.05	$\leq$ 1.55
Multi Tank Conveyor	$\leq$ 0.79	$\leq$ 0.79	$\leq$ 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[2] minimum threshold (50%) and the current year baseline efficiency (35%). [2]

High Efficiency:

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR efficiency requirements as follows[3] :

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:[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[5]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	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[6] .

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 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_serviceAugust 27, 2021 ENERGY STAR Calculator - New Baselines and Efficiencies 082721
4 : 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

Measure Code	COM-FSE-REFFRE
Market	Commercial
Program Type	Lost Opportunity, New Construction, Time of Sale
Category	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 [1]

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[2]:

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	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.[4]

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 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 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

Measure Code	COM-HVAC-BSC
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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

Measure Code	COM-HVAC-CP
Market	Commercial
Program Type	Replace on Burnout
Category	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.[1]

Size	Type	kW	kWh
<= 1 HP	Hydronic Heating	ΔkW = 0.245 * HPrated + 0.02	ΔkWh = 1,325 * HPrated+ 111
	Service Hot Water	ΔkW = 0.245 * HPrated+ 0.02	ΔkWh = 2,780 * HPrated+ 233
> 1 HP	Hydronic Heating	ΔkW = 0.265	ΔkWh = 1,436
	Service Hot Water	ΔkW = 0.265	ΔkWh = 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.3

Coincidence Factors:

Coincidence factors are based on best information available. [4]

Impact Factors for Calculating Net Savings:

Statewide net impact factors are based on an Upstream HVAC Net-to-Gross study in Massachusetts in 2021.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-HVAC-CWHB
Market	Commercial
Program Type	New Construction, Retrofit
Category	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.[1]

Measure Name	ΔMMBtu
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 >=90% or AFUE>=95%.

Measure Life:

The measure life is 20 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Combo Condensing Boiler/Water Heater	CI_NB&MR 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Combo Condensing Boiler/Water Heater	CI_NB&MR 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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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:

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

Measure Code	COM-HVAC-CFWH
Market	Commercial
Program Type	Retrofit
Category	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.[1]

Δ Therms = heating load * (1/AFUEbase – 1/AFUEee) = 584 *(1/0.85 – 1/0.97) = 85 therms.

The water heating load is 139 therms.[2]

Δ Therms = water heating load * (1/UEFbase – 1/UEFee) = 139 *(1/0.63 – 1/0.90) = 66 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.[3]

High Efficiency:

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

Measure Life:

The measure life is 18 years.[4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Endnotes:

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

Measure Code	COM-HVAC-WT
Market	Commercial
Program Type	Retrofit
Category	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[1] . 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	ΔkWh	ΔkW[2]	Δ 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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Net to gross factors for attached low rise and high rise is based on evaluation results.[5] [6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6] 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

Measure Code	COM-HVAC-B
Market	Commercial
Program Type	Time of Sale
Category	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.[1]

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.[2]

High Efficiency:

High efficiency is per table efficiency thresholds above.

Measure Life:

The measure life is 20 years.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[5]

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

Measure Code	COM-HVAC-CUH
Market	Commercial
Program Type	Retrofit
Category	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.[1]

Measure Name	ΔMMBtu
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[2].

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[3] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Unit Heater	CI_NB&MR 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_P	SO_{NP}	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.[5]

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

Measure Code	COM-R-CNC
Market	Commercial
Program Type	Retrofit
Category	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:

ΔkWh = (Width) x (Save) x (Hours)
ΔkW = (Width) x (Save)

Where:
ΔkWh = Energy Savings
ΔkW = Connected load reduction
Width = Width of the opening that the night covers protect (ft)
Save = Savings factor based on the temperature of the case (kW/ft). See table below[1]
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.[2] [3]

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_E[6]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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)

Measure Code	COM-HVAC-DEEC
Market	Commercial
Program Type	Retrofit
Category	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:

$\Delta kWh = (kBtu/h)(1\ Ton/12\ kBtu/h)(SAVEkWh)$
$\Delta kWh = (kBtu/h)(1\ Ton/12\ kBtu/h)(SAVEkW)$

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[1]
SAVEkW = Average kW reduction per ton of cooling capacity: 0.289 kW/ton[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]
- Unitil realization rates same as Unitary AC.

Coincidence Factors:

- All PAs on-peak CFs based 2011 NEEP C&I Unitary AC Loadshape Project[5]

Impact Factors for Calculating Net Savings:

Measure	Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

Non-Energy Impacts:

Measure Name	Core Initiative	PA	Annual $ per kWh	Annual $ per Therm
Dual Enthalpy Economizer Controls (DEEC)	CI_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

Measure Code	COM-HVAC-DI
Market	Commercial
Program Type	Retrofit
Category	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.[1]

Measure Name	ΔkWh/sq ft	ΔkW/sq ft	ΔMMBtu/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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Impact Factors for Calculating Net Savings:

Impact factors are from the 2021 C&I NTG evaluation.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[5]

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

Measure Code	COM-HVAC-DIREU
Market	Commercial
Program Type	Retrofit
Category	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.[1] 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Impact Factors for Calculating Net Savings:

Net-to-gross factors are from evaluation results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-HVAC-DS
Market	Commercial
Program Type	Retrofit
Category	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:
ΔMMBtu = MMBtu x Units

Where:
Unit = Number of square feet of ductwork treated
MMBtu = Average annual MMBtu savings per unit: 0.094[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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 [4]

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

Measure Code	COM-HVAC-DS-REU
Market	Commercial
Program Type	Retrofit
Category	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:

MMBtu = Annual Heating Consumption x % SAVE x 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[1]
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

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.[4]

Impact Factors for Calculating Net Savings:

Net to gross factors based on evaluation results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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:

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

Measure Code	COM-HVAC-XXZ
Market	Commercial
Program Type	Retrofit
Category	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[1]:

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 = conditionared 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^2)	-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^2)	-2.66	-2.02	-3.06	-0.89	-1.66	-1.20	-1.41	-0.81	-2.04
	Oil Savings (MMbtu/ ft^2)	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^2)	-0.0011	-0.0008	-0.0013	-0.0004	-0.0007	-0.0005	-0.0006	-0.0003	-0.0009
	Electric Savings (kWh/ft^2)	-4.34	-3.29	-4.99	-1.46	-2.70	-1.96	-2.31	-1.32	-3.33
	Propane Savings (MMbtu/ ft^2)	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.[4] For oil the baseline is an existing inefficient furnace at 78% AFUE furnace.[5]
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.[6]

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[7]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}

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_P	SO_{NP}	NTG[9]
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
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

Measure Code	COM-HVAC-XXX
Market	Commercial
Program Type	Retrofit
Category	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:
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline HP equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of new efficient HP equipment.
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline HP equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of new efficient HP equipment.
EER_{BASE} = Energy Efficiency Ratio of baseline HP equipment
EER_{EE} = Energy Efficiency Ratio of new efficient HP equipment
$EFLH_{COOL}$ = Cooling mode equivalent full load hours. See notes and table for default values.
$EFLH_{HEAT}$ = 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.[1] 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	$EFLH_{cool}$	$EFLH_{heat}$
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:[2]

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[3]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG[8]
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
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

Measure Code	COM-HVAC-XXJ
Market	Commercial
Program Type	Retrofit
Category	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[1]:

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^2)	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	0.0001
	Electric Savings (kWh/ft^2)	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.[6]

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[7]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG[9]
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 [10]

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

Measure Code	COM-HVAC-XXK
Market	Commercial
Program Type	Retrofit
Category	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 [2] :

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 = conditionared 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^3)	-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[4])	-2.17	-1.64	-2.49	-0.73	-1.35	-0.98	-1.15	-0.66	-1.66
	Oil Savings (MMbtu/ft[5])	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[6])	-0.0008	-0.0006	-0.0009	-0.0003	-0.0005	-0.0004	-0.0004	-0.0002	-0.0006
	Electric Savings (kWh/ft[7])	-3.74	-2.84	-4.30	-1.25	-2.33	-1.82	-1.98	-1.14	-2.87
	Propane Savings (MMbtu/ft[8])	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.[4] For oil the baseline is an existing inefficient furnace at 75% AFUE boiler.[5]
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.[6]

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[7]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}

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_P	SO_{NP}	NTG[9]
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
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

Measure Code	COM-HVAC-XXY
Market	Commercial
Program Type	Retrofit
Category	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 (CI_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:
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline HP equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of new efficient HP equipment.
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline HP equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of new efficient HP equipment.
EER_{BASE} = Energy Efficiency Ratio of baseline HP equipment
EER_{EE} = Energy Efficiency Ratio of new efficient HP equipment
$EFLH_{COOL}$ = Cooling mode equivalent full load hours. See notes and table for default values.
$EFLH_{HEAT}$ = 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.[1] 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	$EFLH_{cool}$	$EFLH_{heat}$
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:[2]

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[3]	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	NTG[8]
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
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

Measure Code	COM-HVAC-EMS
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[3]
- Eversource, CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[4]
- 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.[5]

Coincidence Factors:

- National Grid: CFs are custom calculated.
- Eversource, CLC, Unitil: on-peak CFs based on standard assumptions.[6]

Impact Factors for Calculating Net Savings:

Impact factors from 2021 C&I NTG evaluation.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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_RETRO	All			$0.156			
Energy Management System (turnkey)	CI_RETRO	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

Measure Code	COM-HVAC-F
Market	Commercial
Program Type	Time of Sale
Category	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.[1]

Measure Name	ΔMMBtu	ΔkWh[2]	ΔkW
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Furnaces	CI_EQUIP	All	37.3%	2.6%	19.1%	84.4%

Non-Energy Impacts:

Impact factors are deemed from the study results.[4]

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

Measure Code	COM-HVAC-HP-C
Market	Commercial
Program Type	Retrofit
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[1]

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_P	SO_{NP}	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.[2]

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

Measure Code	COM-HVAC-FS
Market	Commercial
Program Type	Lost Opportunity
Category	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[1] 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[2] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}[3]	CF_{WP}
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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}[3]	CF_{WP}
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_P	SO_{NP}	NTG [4]
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.[5]

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:

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

Measure Code	COM-HVAC-HPS
Market	Commercial
Program Type	Replace on Burnout
Category	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:
ΔkWh_{COOL} = Gross annual cooling mode kWh savings from the measure.
ΔkWh_{HEAT} = Gross annual heating mode kWh savings from the measure.
ΔkW_{COOL} = Gross annual kW savings from the measure. Heating kW savings are negligible.
$kBtu/h$[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[2]
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:[3] See notes and table below for values.

Note: Average cooling EFLHs are from the 2010 NEEP HVAC Loadshape study.[4] 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.[5]

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:[8]

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	≥ 760 kBtuh (≥ 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	≥ 65 kBtuh and < 240 kBtuh (≥ 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	≥ 240 kBtuh (≥ 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.[9]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[10]
- Eversource and CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[11]
- Unitil realization rates same as Unitary AC.

Coincidence Factors:

CFs based 2011 NEEP C&I Unitary HVAC Loadshape Project.[12]

Impact Factors for Calculating Net Savings:

Upstream Heat Pumps are based on a HVAC Upstream study which developed statewide net-to-gross results.[13]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-HVAC-HEC
Market	Commercial
Program Type	Retrofit
Category	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 calculated energy and demand savings based on site-specific chiller plant details including specific chiller plan equipment, operational staging, operating load profile and load profile.

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:
kWh = Tons * (12/EERbase - 12/EERee) * Hours
kW = Tons * (12/EERbase - 12/EERee)

Water-Cooled Chillers:

kWh = Tons * (kWtonbase - kWtonee) * Hours
kW = Tons * (kWtonbase - kWtonee) * (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[1] :

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Chillers – IPLV used	CI_NB&MR CI_EQUIP	All	1.00	1.00	1.00	1.00	1.00	0.49	0.06
Chillers – FL used	CI_NB&MR 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[3] . Realization rates assume PA use of the prescriptive algorithms detailed above.

Coincidence Factors:

- CFs based on prospective statewide results from 2015 prescriptive chiller study[4] . 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[5] . Net savings factors for CI_NB&MR initiative are based on 2021 NRNC Study (paths 3&4)[6] . Net savings factors for CI_EQUIP initiative are based on 2021 Omnibus NTG Study (prescriptive).

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-HVAC-HECU
Market	Commercial
Program Type	Retrofit
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	COM-HVAC-HOS
Market	Commercial
Program Type	Retrofit
Category	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:
delkWh = $SAVE_{kWh}$
delkW = $SAVE_{kW}$

Where:
Unit = Installed hotel room occupancy sensor
$SAVE_{kWh}$ = Average annual kWh reduction per unit: 438 kWh[1]
$SAVE_{kW}$ = Average annual kWh reduction per unit: 0.09 kW[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]
- Unitil: Energy and demand RRs are set to 100% due to no formal evaluations have been completed.[5]

Coincidence Factors:

- National Grid: CFs based on engineering estimates.[6]
- Eversource, CLC, Unitil: on-peak CFs based on standard assumptions. [7]

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[9]

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

Measure Code	COM-HVAC-IH
Market	Commercial
Program Type	Time of Sale
Category	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.[1]

Measure Name	ΔMMBtu
Infrared Heaters	12.0

Baseline Efficiency:

The baseline efficiency case is a standard efficiency gas-fired unit heater with combustion efficiency of 80%.

High Efficiency:

The high efficiency case is a gas-fired low-intensity infrared heating unit.

Measure Life:

The measure life is 17 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Infrared Heaters	CI_NB&MR 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Infrared Heaters	CI_NB&MR 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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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:

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)

Measure Code	COM-HVAC-PWS
Market	Commercial
Program Type	Retrofit
Category	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" (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.[1]

Measure Name	ΔMMBtu 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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[4]

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_DImeasures_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

Measure Code	COM-HVAC-PWREU
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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_DImeasures_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

Measure Code	COM-HVAC-PTREU
Market	Commercial
Program Type	Retrofit
Category	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[1] [2] [3]

Measure Name	ΔkWh	ΔkW[4]	ΔMMBtu
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.[5] The measure persistence was estimated to be 69%[6] 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-HVAC-PT
Market	Commercial
Program Type	Retrofit
Category	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
$SAVE_{kWh}$ = average annual kWh reduction per SQFT of controlled (see below)
$SAVE_{kW}$ = average kW reduction per SQFT of controlled space (see below)

Measure Name	SAVEkWh (kWh/SqFt)[1]	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[2]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[3]

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.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[5] .

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	

Endnotes:

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

Measure Code	COM-HVAC-PTG
Market	Commercial
Program Type	Retrofit
Category	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.[1]

Measure Name	ΔMMBtu
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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [4]

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

Measure Code	COM-HVAC-UAC
Market	Commercial
Program Type	New Construction
Category	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:
ΔkWh = (kBtu/h) (1/SEERbase – 1/ SEERee) (EFLHcool)
ΔkW = (kBtu/h) (1/EERbase – 1/ EERee)
For units with cooling capacities equal to or greater than 65 kBtu/h and EER available:
ΔkWh = (kBtu/h) (1/EERbase – 1/ EERee) (EFLHcool)
ΔkW = (kBtu/h) (1/EERbase – 1/ EERee)

For units with cooling capacities equal to or greater than 65 kBtu/h and IEER available:

ΔkWh = (kBtu/h) (1/IEERbase – 1/ IEERee) (Hourscool) (Capadj)

ΔkW = (kBtu/h) (1/EERbase – 1/ EERee)

Where;
ΔkWh = Gross annual kWh savings from the measure.
ΔkW = Gross connected kW savings from the measure.
kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h)
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[1]

PA specific Capacity Adjustment Factors for IEER

PA	Capacity Adjustment Factor
National Grid	1.009
Eversource 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 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 12.9 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 12.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 12.2 IEER	

	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 11.6 IEER	
		All other	Split System and Single Package	9.8 EER 11.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 11.2 IEER	
		All other	Split System and Single Package	9.5 EER 11.0 IEER	
Air conditioners, water cooled	< 65,000 Btu/h	All	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.1 EER 13.9 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.5 EER 13.9 IEER	
		All other	Split System and Single Package	12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.4 EER 13.6 IEER	
		All other	Split System and Single Package	12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 13.5 IEER	
		All other	Split System and Single Package	12.0 EER 13.3 IEER	
Air conditioners, evaporatively cooled	< 65,000 Btu/h	All	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 340/360

		All other	Split System and Single Package	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.7 EER 11.9 IEER	
		All other	Split System and Single Package	11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.5 EER 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Coincidence Factors:

CFs based 2011 NEEP C&I Unitary HVAC Loadshape Project.4

Impact Factors for Calculating Net Savings:

NTG values were developed as part of an upstream HVAC NTG study in 2021 in Massachusetts.[5]

Measure	Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-WH-CWH
Market	Commercial
Program Type	Replace on Burnout
Category	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.[1]

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%.[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Endnotes:

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

Measure Code	COM-WH-FA
Market	Commercial
Program Type	Retrofit
Category	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[1,2]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[3]

High Efficiency:

The high efficiency case is a faucet with 1.5 GPM or less aerator installed.[4]

Measure Life:

The measure life is 3 years.[5]

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.[6]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[7]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[9]

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

Measure Code	COM-WH-FAREU
Market	Commercial
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW	Δ 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.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[6]

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

Measure Code	COM-WH-IWH
Market	Commercial
Program Type	Replace on Burnout
Category	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.[1]

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 purposed of estimating standby losses.[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

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

Measure Code	COM-WH-LFSH
Market	Commercial
Program Type	Retrofit
Category	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.[1] mmBTU savings for delivered fuels assumed to be in a 1:1 ratio with already existing gas measure.

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[2]

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.[3]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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

Measure Code	COM-WH-SREU
Market	Commercial
Program Type	Retrofit
Category	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.[1] kW savings are calculated using the Demand Impact Model.[2]

Measure Name	ΔkWh	ΔkW	Δ 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. [3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-WH-STV-REU
Market	Commercial
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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)

Measure Code	COM-WH-PWWH
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Impact Factors for Calculating Net Savings:

Values are based on an evaluation study.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[5]

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_DImeasures_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

Measure Code	COM-WH-PWREU
Market	Commercial
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

Savings for Pipe Wrap (Water Heating):

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

Impact Factors for Calculating Net Savings:

Net to Gross factors are based on evaluation results.[5]

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.

Endnotes:

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

Measure Code	COM-WH-PRSV
Market	Commercial
Program Type	Retrofit
Category	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.[1] mmBTU savings for delivered fuel products assumed to be at a 1:1 relationship with already existing gas measure.

Measure Name	ΔMMBtu	ΔkWh	ΔkW
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.[2]

Measure Life:

The measure life is 3 years.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Values from 2021 C&I NTG study. [6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6]

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

Measure Code	COM-WH-STV
Market	Commercial
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2] MMBtu savings assumed to be at 1:1 relationship with already existing gas measure.

Measure Name	ΔkWh	ΔkW	ΔMMBtu
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.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net to gross values based on evaluated numbers.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [7]

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

Measure Code	COM-HVAC-ST
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Steam Trap	CI_RETRO	All	0.369	0.00	0.032	0.663

Non-Energy Impacts:

NEIs are from 2021 Study.[4]

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

Measure Code	COM-WH-TWH
Market	Commercial
Program Type	Replace on Burnout
Category	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.

$$Annual\ Energy\ Savings\ (therms) = \frac{365 \times \rho_W \times Temperature\ Rise}{100{,}000\ \frac{Btu}{therm}} \times \left(\frac{1}{EF_{installed}} - \frac{1}{EF_{baseline}}\right) \times GPD$$

Temperature Rise = 80 (°F)
GPD = building specific per table below
$EF_{Baseline}$ = 0.71
$EF_{Installed}$ = 0.94
Water Density (p_w) = 8.33

Building Type GPD Table[1]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4] 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[5] .

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-WH-TVREU
Market	Commercial
Program Type	Retrofit
Category	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.[1] kW savings are calculated using the demand impact model.[2]

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.[3]

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.[4]

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[5]

Impact Factors for Calculating Net Savings:

Net to gross factors based on evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-WH-VWH
Market	Commercial
Program Type	Replace on Burnout
Category	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[1] .

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[2] .

High Efficiency:

The high efficiency case is a volume water heater with a 94% TE.

Measure Life:

The measure life is 15 years.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[4] . 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[5] .

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

Measure Code	COM-L-FREU
Market	Commercial
Program Type	Retrofit
Category	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 (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	EC2a095
LED Fixture, Linear Indoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	EC2a096
LED Fixture, Outdoor Common Area (Residential End Use)	C&I Existing Building Retrofit (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

Measure Code	COM-L-LC
Market	Commercial
Program Type	Retrofit
Category	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:
$\Delta kWh = ControlledkW * Hours_{base} * (\%_{Sav})$
$\Delta kW = (ControlledkW)$

C&I Small Business:
$\Delta kWh = (ControlledkW) (Hours_{base} - Hours_{ee})$
$\Delta kW = (ControlledkW)$

Where:
Controlled kW = Controlled fixture wattage
$\%_{Sav}$ = Percentage of kWh that is saved by utilizing the control measure.
$Hours_{BASE}$ = Total annual hours that the connected Watts operated in the pre-retrofit case (retrofit installations) or would have operated with code-compliance controls (new construction installations).
$Hours_{EE}$ = Annual hours that the connect Watts operate with controls implemented

Savings factors are deemed based on study results or engineering calculated.[1]

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.[2]

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 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 CI_NB&MR CI_EQUIP	All	1.00	1.03	1.03	0.94	0.94	0.15	0.13
Lighting Controls – Occupancy Sensor	CI_RETRO CI_NB&MR CI_EQUIP	All	1.00	1.03	1.03	0.94	0.94	0.15	0.13
Lighting Controls – Dual Sensor/Other	CI_RETRO CI_NB&MR CI_EQUIP	All	1.00	1.03	1.03	0.94	0.94	0.15	0.13
Lighting Controls – Exterior	CI_RETRO CI_NB&MR 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.[3]
- Small C&I Existing Building Retrofit: RRs from statewide Pre/Post Occupancy Sensor study.[4]

Coincidence Factors:

- Large C&I: CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[5]
- C&I Small Business: CFs from statewide Pre/Post Occupancy Sensor study.[6]

Impact Factors for Calculating Net Savings:

Net-to-gross values are deemed based on study results.[7] [8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-L-FCLED
Market	Commercial
Program Type	Retrofit
Category	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:

$\Delta kWh = \Delta kWh_{LED} + \Delta kWh_{Heat}$
ΔkWh_{LED} = Summation of i=1 to n ($Count_i * kW_i * Hours_i)_{BASE}$ - Summation of i=1 to m $(Count_j * kW_j * Hours_j)_{LED}$
$\Delta kWhheat = \Delta kWh_{LED} * 0.28 * Eff_{RS}$
$\Delta kW = \Delta kWh / Hours_j$

Where:
ΔkWh_{LED} = Reduction in lighting energy
ΔkWh_{Heat} = Reduction in refrigeration energy due to reduced heat loss from the lighting fixtures
N = Total number of lighting fixture types in the pre-retrofit case
M = Total number of lighting fixture types in the post-retrofit case
$Count_i$ = Quantity of type i fixtures in the pre-retrofit case
kW_i = Power demand of pre-retrofit lighting fixture type i (kW/fixture)
$Hours_i$ = Pre-retrofit annual operating hours of fixture type i
$Count_j$ = Quantity of type j fixtures in the pre-retrofit case
kW_j = Power demand of lighting fixture type j (kW/fixture)
$Hours_j$ = Post-retrofit annual operating hours of fixture type j
0.28 = Unit conversion between kW and tons calculated as 3,413 Btuh/kW divided by 12,000 Btuh/ton
EffRS = Efficiency of typical refrigeration system: 1.6 kW/ton for C&I Small Business; 1.9 kW/ton for Large C&I[1]

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.[2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3]

Coincidence Factors:

All PAs CFs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[4]

Impact Factors for Calculating Net Savings:

Net-to-Gross is based on study results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-L-ALD
Market	Commercial
Program Type	Retrofit
Category	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:

$$\Delta kWh = \sum_{i=1}^{n} (LPD_{Base,i} - Controlled \times LPD_{Proposed,i} \times 0.8) \times Area_i \times Hours_i \times 1/1000$$

$$\Delta kW_{Fixture} = \sum_{i=1}^{n} LPD_{Base,i} \times Area_i \times 1/1000 - LPD_{Proposed,i} \times Area_i \times 1/1000$$

$$\Delta kW_{Controlled} = \sum_{i=1}^{n} LPD_{Proposed,i} \times Area_i \times 0.8 \times 1/1000$$

Where:

n = Total number of spaces or 1 for Building Area Method
$LPD_{Base,i}$ = Baseline lighting power density for building or space type i (Watts/ft^2)
$Area_i$ = Area of building or space i (ft^2)
$Hours_i$ = Annual hours of operation of the lighting equipment for space type i
$LPD_{Proposed,i}$ = Proposed lighting power density for building or space type i (Watts/ft^2)
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.[1] 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 CI_RETRO	All	7	6	5
Ambient Linear Fixtures	CI_EQUIP CI_RETRO	All	7	6	5
High/Low Bay Lamps	CI_EQUIP CI_RETRO	All	8	7	6
High/Low Bay TLED	CI_EQUIP CI_RETRO	All	8	7	6
High/Low Bay Fixtures	CI_EQUIP CI_RETRO	All	8	7	6
Exterior/Outdoor Lamps	CI_EQUIP CI_RETRO	All	6	5	4
Exterior/Outdoor TLED	CI_EQUIP CI_RETRO	All	6	5	4
Exterior/Outdoor Fixtures	CI_EQUIP CI_RETRO	All	6	5	4
A-Lamps	CI_EQUIP CI_RETRO	All	2	1	1
Decoratives	CI_EQUIP CI_RETRO	All	2	1	1
Downlights/Track	CI_EQUIP 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.[2]

Measure Name	Core Initiative	PA	MMBtu/kWh
Performance Lighting (Interior)	CI_NB&MR CI_EQUIP	All	-0.000175
Performance Lighting (Exterior)	CI_NB&MR CI_EQUIP	All	n/a
Performance Lighting (Interior w/ Controls)	CI_NB&MR CI_EQUIP	All	-0.000175
Performance Lighting (Exterior w/ Controls)	CI_NB&MR 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Performance Lighting (Interior w/ and w/o Controls)	CI_NB&MR CI_EQUIP 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 CI_EQUIP 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.[3]

Coincidence Factors:

All CFs from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting program.[4]

Impact Factors for Calculating Net Savings:

Factors are deemed based on study results.[5]

Net-to-gross values for the New Buildings and Major Renovations Core Initiative are based on study results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[6] Retrofit non-energy benefits are from the 2012 NEI study.[7]

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

Measure Code	COM-L-LS
Market	Commercial
Program Type	Retrofit
Category	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:

$\Delta kWh = (\text{Summation } i=1 \text{ to } n(Count_i * Watts_i / 1000)_{BASE} - \text{Summation } j=1 \text{ to } n(Count_j * Watts_j / 1000)_{EE})$ (Hours)
$\Delta kW = \text{Summation } i=1 \text{ to } n(Count_i * Watts_i / 1000)_{BASE} - \text{Summation } j=1 \text{ to } n\ (Count_j * Watts_j / 1000)_{EE}$

Where:
n = Total number of fixture types in baseline or pre-retrofit case
m = Total number of installed fixture types
$Count_i$ = Quantity of existing fixtures of type i (for lost-opportunity, $Count_i = Count_j$).
$Watts_i$ = Existing fixture or baseline wattage for fixture type i
$Count_j$ = Quantity of efficient fixtures of type j.
$Watts_j$ = Efficient fixture wattage for fixture type j.
1000 = Conversion factor: 1000 watts per kW.
Hours = Lighting annual hours of operation.

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[1]

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[2]

Building Type	Hours of Use
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.[2] 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 CI_RETRO	All	7	6	5
Ambient Linear Fixtures	CI_EQUIP CI_RETRO	All	7	6	5
High/Low Bay Lamps	CI_EQUIP CI_RETRO	All	8	7	6
High/Low Bay TLED	CI_EQUIP CI_RETRO	All	8	7	6

High/Low Bay Fixtures	CI_EQUIP CI_RETRO	All	8	7	6
Exterior/Outdoor Lamps	CI_EQUIP CI_RETRO	All	6	5	4
Exterior/Outdoor TLED	CI_EQUIP CI_RETRO	All	6	5	4
Exterior/Outdoor Fixtures	CI_EQUIP CI_RETRO	All	6	5	4
A-Lamps	CI_EQUIP CI_RETRO	All	2	1	1
Decoratives	CI_EQUIP CI_RETRO	All	2	1	1
Downlights/Track	CI_EQUIP 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 CI_EQUIP, CI_RETRO	All	-0.000691
Lighting Systems - Exterior	CI_NB&MR 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) 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.[3] Penalties for interior, turnkey are from the 2018 small business lighting impact evaluation[4] . Penalties for upstream lighting products are from the 2017 upstream lighting impact evaluation[5] .

Impact Factors for Calculating Adjusted Gross Savings:

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Lighting Systems - Interior	CI_NB&MR CI_EQUIP, CI_RETRO	All	1.00	1.12	1.12	1.00	1.00	0.80	0.61
Lighting Systems - Exterior	CI_NB&MR CI_EQUIP, 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/ 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.[6]
- 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.[7]
- 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.[8]
- 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.[9]

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.[10]
- C&I Upstream: All PAs CFs are from the 2017 Upstream Lighting Impact evaluation.[11]
- C&I Existing Building Retrofit: All CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[12]
- 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.[13]

Impact Factors for Calculating Net Savings:

2022 Net-to-gross values are based on study results.[14] [15]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[16]

			2022	2022	2023	2023	2024	2024
Measure Name	**Core Initiative**	**PA**	**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/ 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) with Controls	CI_EQUIP	All	0.74	0.26	0.80	0.20	0.86	0.14
Lighting Upstream - LED Exterior with 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.[17]

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

Measure Code	COM-MAD-VFD
Market	Commercial
Program Type	Retrofit
Category	Motors and Drives
Sub Category	Motors and Drives
TRM Version	2022-2024 Plan TRM
Measure Version	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_{SP} = Summer demand reduction based on building and equipment type. See table below.
kW / HP_{WP} = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

Savings Factors for C&I VFDs (kWh/HP[1] and kW/HP[2])

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_{SP})									
University/ College	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Elm/H School	0.377	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Multi-Family	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Hotel/Motel	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Health	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Warehouse	0.109	-0.023	0.174	0.457	0.091	0.261	0.287	0.274	0.218
Restaurant	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Retail	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Grocery	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Offices	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Winter Demand Savings Factors (kW/HP_{WP})									
University/ College	0.377	-0.006	0.184	0.457	0.21	0.109	0.26	0.252	0.282

Elementary/ High School	0.457	-0.006	0.184	0.457	0.21	0.109	0.26	0.252	0.282
Multi-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.[4]

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_E[5]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 [8] .

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.[10]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[11]	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

Measure Code	COM-MAD-VFDREU
Market	Commercial
Program Type	Retrofit
Category	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$_{SP}$ = Summer demand reduction based on building and equipment type. See table below.
kW / HP$_{WP}$ = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

Savings Factors for VFDs[1] [2] (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_{SP})									
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_{WP})									
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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4]

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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-MD-MVFD
Market	Commercial
Program Type	Retrofit
Category	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_{SP} = Summer demand reduction based on building and equipment type. See table below.
kW / HP_{WP} = Winter demand reduction based on building and equipment type. See table below.

Savings factors 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[1] and kW/HP[2]) :

Building Type	Building Exhaust Fan	Cooling Tower	Chilled Water Pump	Boiler Feed Water Pump	Hot Water Circulating Pump	MAF Make-up Air Fan	Return Fan	Supply Fan
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_{SP})								
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_{WP})								
University/ College	0.791	(0.001)	0.384	0.952	0.437	0.257	0.563	0.544
Elementary/ High School	1.428	(0.002)	0.575	1.428	0.655	0.385	0.844	0.816
Multi-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.[3] [4]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}

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.[5] 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.[6]

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.[8]

Net-to-gross values for the New Buildings and Major Renovations Core Initiative are based on study results.[9]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[13]	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
VFD with motor	CI_RETRO 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

Measure Code	COM-CM-CSA
Market	Commercial
Program Type	Lost Opportunity, New Construction
Category	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.[1] 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

Savings (Therms) - Electric Interactive Effects			
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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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_P	SO_{NP}	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

Measure Code	COM-PL-APS
Market	Commercial
Program Type	Retrofit
Category	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.[1] Demand savings are derived from the demand impact model which is developed as part of the Residential Baseline Study.[2]

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_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[3] [4]

Realization Rates

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[5]

Coincidence Factors

From evaluation study. [6]

Impact Factors for Calculating Net Savings:

PAs use state-wide prescriptive net-to-gross values based on the 2021 C&I Omnibus NTG Study. [7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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

Measure Code	COM-R-CMR
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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:
ΔkWh_{Motor} = Energy savings due to increased efficiency of case motor
ΔkWh_{Heat} = Energy savings due to reduced heat from evaporator fans
kW_{motor} = Metered load of case motor
LRF = Load reduction factor: 53% when shaded pole motors are replaced, 29% when PSC motors are replaced.[2]
Hours = Average runtime of case motors (8,500 hours)[3]
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)[4]
ΔkW = 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.[5] [6]

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_E[7]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[8]

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.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[9]

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

Measure Code	COM-R-DHC
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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)[2]

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.[3]

Measure Life:

This measure was determined to have an add on single baseline for retrofit scenarios.[4] [5]

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_E[6]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration -Door Heater Controls	CI_RETRO	Eversource, Unitil	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.[7]

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.[8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[9]

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:

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

Measure Code	COM-R-ECMEFM
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Measure Description:

Installation of various sizes of electronically commutated motors (ECMs) in walk-in coolers and freezers to replace existing evaporator fan motors.[1]

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:
ΔkWh_{Fan} = Energy savings due to increased efficiency of evaporator fan motor
ΔkWh_{Heat} = Energy savings due to reduced heat from the evaporator fans
kW_{Fan} = Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/adjustment[2] : Amps x Voltage x PF x √Phase
LRF = Load reduction factor for motor replacement (65%)[3]
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[4]
ΔkW = 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.[5] [6]

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_E	RR_{NE}[7]	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers	CI_RETRO	Eversource, Unitil	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.[8]

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.[9]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[10]

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

Measure Code	COM-R-EDO
Market	Commercial
Program Type	Early Replacement
Category	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 = (Daily energy consumption * Operating days per year= Annual Energy Consumption(kWh))

Annual Energy Consumption(kWh) standard model - Annual Energy Consumption(kWh) = Energy savings kWh/year.

kW = Average Demand kW * 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 [1]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 [3]

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[4]

Measure Name	PA	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per kWh	Annual $ per Therm	One-time$ 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

Measure Code	COM-R-EDC
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Measure Description:

A control mechanism to skip defrost cycles when defrost is unnecessary.[1]

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:

$\Delta kWh_{Defrost} = kW_{Defrost} \times Hours \times DRF$
$\Delta kWh_{Heat} = \Delta kWh_{Defrost} \times 0.28 \times Eff_{RS}$
$\Delta kWh = \Delta kWh_{Defrost} + \Delta kWh_{Heat}$
$\Delta kW = \Delta kWh/8760$

Where:
$\Delta kWh_{Defrost}$ = Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls.
ΔkWh_{Heat} = Energy savings due to reduced heat from reduced number of defrosts.
$kW_{Defrost}$ = Load of electric defrost.
Hours = Number of hours defrost occurs over a year without the defrost controls.
DRF = Defrost reduction factor- percent reduction in defrosts required per year (35%)[2]
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)[3]
ΔkW = Average demand savings
8,760 = Hours per year

Baseline Efficiency:

The baseline efficiency case is an evaporator fan electric defrost system that uses a time clock mechanism to initiate defrost.

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.[4] [5]

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_E[8]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Electronic Defrost Control	CI_RETRO	Eversource Unitil	1.00	0.95	1.00	1.27	1.42	0.90	0.90
Refrigeration - Electronic Defrost Control	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:

- 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.[7]

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.[8]

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

Measure Code	COM-R-EFC
Market	Commercial
Program Type	New Construction
Category	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.[1]

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:

$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat} + \Delta kWh_{Control}$
$\Delta kWh_{Fan} = kW_{Fan} * 8760 * \%OFF$
$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$
$\Delta kWh_{Control} = [kW_{CP} * Hours_{CP} + kW_{Fan} * 8760 * (1-\%OFF)] * 5\%$
$\Delta kW = \Delta kWh/8760$

Where :
ΔkWh_{Fan}= Energy savings due to evaporator being shut off
ΔkWh_{Heat}= Energy savings due to reduced heat from the evaporator fans
$\Delta kWh_{Control}$ = Energy savings due to the electronic controls on compressor and evaporator
kW_{Fan} = Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/ adjustment[2] : Amps x Voltage x PF x √Phase
%OFF = Percent of annual hours that the evaporator is turned off: 46%[3]
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[4]
kW_{CP} = Total power demand of compressor motor and condenser fan calculated from equipment nameplate data and estimated 0.85 power factor[5] : Amps x Voltage x PF x √Phase
$Hours_{CP}$ = Equivalent annual full load hours of compressor operation: 4,072 hours[6]
5% = Reduced run-time of compressor and evaporator due to electronic temperature controls[7]
ΔkW = Average demand savings
8,760 = Hours per year

Baseline Efficiency:

The baseline efficiency case assumes evaporator fans that run 8,760 annual hours with no temperature control.

High Efficiency:

The high efficiency case is the use of an energy management system to control evaporator fan and compressor operation based on temperature.

Measure Life:

This measures is determined to have an add on single baseline for retrofit scenarios.[8] [9]

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_E[10]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Evaporator Fan Controls	CI_RETRO	Eversource Unitil	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.[12]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[13]

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

Measure Code	COM-R-HR
Market	Commercial
Program Type	Early Replacement
Category	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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[1]

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.[2]

Measure Name	PA	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per kWh	Annual $ per Therm	One-time$ 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

Measure Code	COM-R-LGCS
Market	Commercial
Program Type	Early Replacement
Category	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 [1]

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.	≤ 0.184*V + 3.5 kWh/day, V=unit volume
Laboratory Grade High Performance Refrigerators, 25≤V<44 cu. ft.	≤ 0.153*V + 4.28 kWh/day
Laboratory Grade High Performance Refrigerators, ≥44 cu. ft.	≤ 0.125*V + 5.5 kWh/day
Laboratory Grade High Performance Freezers, 6≤V<22 cu. ft.	≤ 0.09*V + 10 kWh/day
Laboratory Grade High Performance Freezers, ≥22 cu. ft.	≤ 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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [2]

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

Measure Code	COM-R-NCS
Market	Commercial
Program Type	Retrofit
Category	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.[1]

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[2]
$Hours_{OFF}$ = 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%[3]

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 measures is determined to have an add on single baseline for retrofit scenarios.[4] [5]

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_E[8]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[8]

Coincidence Factors:

Coincidence factors representative of C&I Refrigeration.

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.[7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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.[8]

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

Measure Code	COM-R-RCB
Market	Commercial
Program Type	Early Replacement
Category	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 (# 0f 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[1]

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 [2]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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. [3]

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. [4]

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

Measure Code	COM-R-VM
Market	Commercial
Program Type	Retrofit
Category	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:

$\Delta kWh = (kW_{rated})(Hours)(SAVE)$
$\Delta kW = \Delta kWh / Hours$

Where:
kW_{rated} = Rated kW of connected equipment. Seefor 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[1]

Equipment Type	kW_{rated}	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.[2]

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_E[8]	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
All Vending Misers	CI_RETRO	National Grid Unitil	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.[8]

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.[4] PAs use results from a multi family evaluation for the residential end use.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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. [7]

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

Measure Code	COM-BE-RNC
Market	Commercial
Program Type	New Construction
Category	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.[1]

The Multifamily High-Rise baseline is evaluated separately.[2]

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.[3]

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_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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.[4] 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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	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[3]

Building Type	2018 IECC LPD (W/ft^2)	2018 IECC w/ MA enhancements LPD (W/ft^2)
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

[3] IECC 2018 Interior Lighting Power Allowances: Building Area method, adapted from Table C405.3.2(1) with adjustments for MA code enhancements

Building Type	**2018 IECC LPD (W/ft^2)**	**2018 IECC w/ MA enhancements LPD (W/ft^2)**
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[4]

Common Space Types	**LPD Allowances, W/ft2**
Atrium	
<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
Audience Seating Area	
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
Banking Activity Area	0.86
Breakroom (See Lounge/Breakroom)	
Classroom/Lecture Hall/Training Room	
Penitentiary	1.34
All other classrooms/lecture halls/training rooms	0.92
Conference/Meeting/Multipurpose Room	1.07
Confinement Cells	0.81
Copy/Print Room	0.56

[4] IECC 2018 Interior Lighting Power Allowances: Space-by-Space Method, Table C405.3.2(2)

Common Space Types	**LPD Allowances, W/ft2**
Corridor[2]	
Facility for the visually impaired (and not used primarily by the staff)[3]	0.92
Hospital	0.92
Manufacturing facility	0.29
All other corridors	0.66
Courtroom	1.39
Computer Room	1.33
Dining Area	
Penitentiary	0.96
Facility for the visually impaired (and not used primarily by staff)[3]	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
Electrical/Mechanical Room[7]	0.43
Emergency Vehicle Garage	0.41
Food Preparation Area	1.06
Guest Room	0.77
Laboratory	
In or as a classroom	1.2
All other laboratories	1.45
Laundry/Washing Area	0.43
Loading Dock, Interior	0.58
Lobby	

Common Space Types	**LPD Allowances, W/ft2**
Facility for the visually impaired (and not used primarily by the staff)[3]	2.03
Elevator	0.69
Hotel	1.06
Motion picture theater	0.45
Performing arts theater	1.7
All other lobbies	1
Locker Room	0.48
Lounge/Breakroom	
Healthcare facility	0.78
All other lounges/breakrooms	0.62
Office	
Enclosed and ≤250 ft^2	0.93
Enclosed and >250 ft^2	0.93
Open plan	0.81
Parking Area, Interior	0.14
Pharmacy Area	1.34
Restroom	
Facility for the visually impaired (and not used primarily by the staff)[3]	0.96
All other restrooms	0.85
Sales Area[4]	1.22
Seating Area, General	0.42

Common Space Types	**LPD Allowances, W/ft2**
Stairway	The *space* containing the stairway shall determine the *LPD* and *control* requirements for the stairway.
Stairwell	0.58
Storage Room	
<50 ft^2	0.97
≥50 ft^2 and ≤ 1000 ft^2	0.46
All other storage rooms	0.46
Vehicular Maintenance Area	0.56
Workshop	1.14
Facility for the Visually Impaired[3]	
Chapel (used primarily by residents)	1.06
Recreation room/common living room (and not used primarily by staff)	1.8
Automotive (See "Vehicular Maintenance Area")	
Convention Center—Exhibit Space	0.88
Dormitory—Living Quarters	0.54
Fire Station—Sleeping Quarters	0.2
Gymnasium/Fitness Center	
Exercise area	0.5
Playing area	0.82
Healthcare Facility	
Exam/treatment room	1.68
Imaging room	1.06

Common Space Types	**LPD Allowances, W/ft2**
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
Library	
Reading area	0.82
Stacks	1.2
Manufacturing Facility	
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
Museum	
General exhibition area	1.05
Restoration room	0.85
Performing Arts Theater—Dressing Room	0.36
Post Office—Sorting Area	0.68
Religious Facility	
Fellowship hall	0.55

Common Space Types	**LPD Allowances, W/ft2**
Worship/pulpit/choir area	1.53
Retail Facilities	
Dressing/fitting room	0.5
Mall concourse	0.9
Sports Arena—Playing Area[8]	
Class I facility	2.47
Class II facility	1.96
Class III facility	1.7
Class IV facility	1.13
Transportation Facility	
Baggage/carousel area	0.45
Airport concourse	0.31
Terminal ticket counter	0.62
Warehouse—Storage Area	
Medium to bulky, palletized items	0.35
Smaller, hand-carried items[5]	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
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	04
1L005	5 WATT LED	05
1L006	6 WATT LED	06
1L007	7 WATT LED	07
1L008	8 WATT LED	08
1L009	9 WATT LED	09
1L010	10 WATT LED	10
1L011	11 WATT LED	11
1L012	12 WATT LED	12
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
LED Exit Signs		
1E0002	2.0 WATT LED	2
1E0003	3.0 WATT LED	3
1E0005	5.0 WLED	5
1E0005C	0.5 WATT LEC	0.5
1E0008	8.0 WLED	8
1E0015	1.5 WATT LED	1.5
1E0105	10.5 WATT LED	10.5
T5 Systems		
1F14SSE	1L2’ 14W T5/ELIG	16
1F21SSE	1L3’ 21W T5/ELIG	24
1F24HSE	1L2’ 24W T5HO/ELIG	29
1F28SSE	1L4’ 28W T5/ELIG	32
1F39HSE	1L3’ 39W T5HO/ELIG	42
1F47HSE	1L4’ 47W T5HO/ELIG	53
1F50HSE	1L4’ 50W T5HO/ELIG	58
1F54HSE	1L4’ 54W T5HO/ELIG	59
2F14SSE	2L2’ 14W T5/ELIG	32
2F21SSE	2L3’ 21W T5/ELIG	47
2F24HSE	2L2’ 24W T5HO/ELIG	52
2F28SSE	2L4’ 28W T5/ELIG	63
2F39HSE	2L3’ 39W T5HO/ELIG	85
2F47HSE	2L4’ 47W T5HO/ELIG	103

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
Two-Foot-High Efficient T8 Systems		
1F17ESL	1L2' 17W T8EE/ELEE LOW PWR	14
1F17ESN	1L2' 17W T8EE/ELEE	17
1F17ESH	1L2' 17W T8EE/ELEE HIGH PWR	20
1F28BXE	1L2' F28BX/ELIG	32
2F17ESL	2L2' 17W T8EE/ELEE LOW PWR	27
2F17ESN	2L2' 17W T8EE/ELEE	32
2F17ESH	2L2' 17W T8EE/ELEE HIGH PWR	40
2F28BXE	2L2' F28BX/ELIG	63
3F17ESL	3L2' 17W T8EE/ELEE LOW PWR	39
3F17ESN	3L2' 17W T8EE/ELEE	46
3F17ESH	3L2' 17W T8EE/ELEE HIGH PWR	61
3F28BXE	3L2' F28BX/ELIG	94
Three-Foot-High Efficient T8 Systems		
1F25ESL	1L3' 25W T8EE/ELEE LOW PWR	21
1F25ESN	1L3' 25W T8EE/ELEE	24
1F25ESH	1L3' 25W T8EE/ELEE HIGH PWR	30
2F25ESL	2L3' 25W T8EE/ELEE LOW PWR	40
2F25ESN	2L3' 25W T8EE/ELEE	45
2F25ESH	2L3' 25W T8EE/ELEE HIGH PWR	60
3F25ESL	3L3' 25W T8EE/ELEE LOW PWR	58
3F25ESN	3L3' 25W T8EE/ELEE	67
3F25ESH	3L3' 25W T8EE/ELEE HIGH PWR	90
Four Foot T8 High Efficient / Reduce Wattage Systems		
1F25EEH	1L4' 25W T8EE/ELEE HIGH PWR	30
1F25EEE	1L4' 25W T8EE/ELEE	22
1F25EEL	1L4' 25W T8EE/ELEE LOW PWR	19
2F25EEH	2L4' 25W T8EE/ELEE HIGH PWR	57
2F25EEE	2L4' 25W T8EE/ELEE	43
2F25EEL	2L4' 25W T8EE/ELEE LOW PWR	37
3F25EEH	3L4' 25W T8EE/ELEE HIGH PWR	86
3F25EEE	3L4' 25W T8EE/ELEE	64
3F25EEL	3L4' 25W T8EE/ELEE LOW PWR	57
4F25EEH	4L4' 25W T8EE/ELEE HIGH PWR	111
4F25EEE	4L4' 25W T8EE/ELEE	86
4F25EEL	4L4' 25W T8EE/ELEE LOW PWR	75
1F28EEH	1L4' 28W T8EE/ELEE HIGH PWR	33
1F28EEE	1L4' 28W T8EE/ELEE	24
1F28EEL	1L4' 28W T8EE/ELEE LOW PWR	22

Device Code	Device Description	Rated Watts
2F28EEH	2L4' 28WT8EE/ELEE HIGH PWR	64
2F28EEE	2L4' 28W T8EE/ELEE	48
2F28EEL	2L4' 28W T8EE/ELEE LOW PWR	42
3F28EEH	3L4' 28W T8EE/ELEE HIGH PWR	96
3F28EEE	3L4' 28W T8EE/ELEE	72
3F28EEL	3L4' 28W T8EE/ELEE LOW PWR	63
4F28EEH	4L4' 28W T8EE/ELEE HIGH PWR	126
4F28EEE	4L4' 28W T8EE/ELEE	94
4F28EEL	4L4' 28W T8EE/ELEE LOW PWR	83
1F30EEH	1L4' 30W T8EE/ELEE HIGH PWR	36
1F30EEE	1L4' 30W T8EE/ELEE	26
1F30EEL	1L4' 30W T8EE/ELEE LOW PWR	24
2F30EEH	2L4' 30WT8EE/ELEE HIGH PWR	69
2F30EEE	2L4' 30W T8EE/ELEE	52
2F30EEL	2L4' 30W T8EE/ELEE LOW PWR	45
3F30EEH	3L4' 30W T8EE/ELEE HIGH PWR	103
3F30EEE	3L4' 30W T8EE/ELEE	77
3F30EEL	3L4' 30W T8EE/ELEE LOW PWR	68
4F30EEH	4L4' 30W T8EE/ELEE HIGH PWR	133
4F30EEE	4L4' 30W T8EE/ELEE	101
4F30EEL	4L4' 30W T8EE/ELEE LOW PWR	89
1F32EEH	1L4' 32W T8EE/ELEE HIGH PWR	38
1F32EEE	1L4' 32W T8EE/ELEE	28
1F32EEL	1L4' 32W T8EE/ELEE LOW PWR	25
2F32EEH	2L4' 32W T8EE/ELEE HIGH PWR	73
2F32EEE	2L4' 32W T8EE/ELEE	53
2F32EEL	2L4' 32W T8EE/ELEE LOW PWR	47
3F32EEH	3L4' 32W T8EE/ELEE HIGH PWR	109
3F32EEE	3L4' 32W T8EE/ELEE	82
3F32EEL	3L4' 32W T8EE/ELEE LOW PWR	72
4F32EEH	4L4' 32W T8EE/ELEE HIGH PWR	141
4F32EEE	4L4' 32W T8EE/ELEE	107
4F32EEL	4L4' 32W T8EE/ELEE LOW PWR	95
5F32EEH	5L4' 32W T8EE/ELEE HIGH PWR	182
6F28EEE	6L4' 28W T8EE/ELEE	144
6F28EEH	6L4' 28W T8EE/ELEE HIGH PWR	192
6F28EEL	6L4' 28W T8EE/ELEE LOW PWR	126
6F30EEE	6L4' 30W T8EE/ELEE	154
6F30EEL	6L4' 30W T8EE/ELEE 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
Eight Foot T8 Systems		
1F59SSE	1L8’ T8/ELIG	60
1F80SSE	1L8’ T8 HO/ELIG	85
2F59SSE	2L8’ T8/ELIG	109
2F59SSL	2L8’ T8/ELIG LOW PWR	100
2F80SSE	2L8’ T8 HO/ELIG	160
Tandem Wired T8 High Efficient		
2W32EEE	2L4’ TW T8EE/ELIG	27
2W32EEL	2L4’ TW T8EE/ELEE LOW PWR	24
3W32EEE	3L4’ TW T8EE/ELIG	39
3W32EEL	3L4’ TW T8EE/ELEE LOW PWR	34
4W32EEE	4L4’ TW T8EE/ELIG	51
4W32EEL	4L4’ TW T8EE/ELEE LOW PWR	45
Tandem-Wired Fluorescent Systems		
2W32SSE	2L4’ TW T8/ELIG	30
2W32SSH	2L4’ TW T8/HI-LUM	39
2W40SEE	2L4’ TW EE/ELIG	30
2W40SSE	2L4’ TW STD/ELIG	36
2W59HSE	2L8’ TW T8 HO/ELIG	80
2W59SSE	2L8’ TW T8/ELIG	55
2W96HEE	2L8’ TW HO-EE/ELIG	85
2W96HSE	2L8’ TW HO-STD/ELIG	98
2W96SEE	2L8’ TW EE/ELIG	55
2W96SSE	2L8’ TW STD/ELIG	67
3W32SSE	3L4’ TW T8/ELIG	29
4D17SSE	4L2’ TW T8/ELIG	31
4D32EEE	4L4’ DTW T8EE/ELIG	51
4D32EEL	4L4’ DTW T8EE/ELEE LOW PWR	45
4D32SSE	4L4’ DTW T8/ELIG	53
4D32SSL	4L4 DTWT8/ELIG LOW POWER	49
4W32SSE	4L4’ TW T8/ELIG	27
4W32SSL	4L4 TWT8/ELIG LOW POWER	25
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	4
1L005	5 WATT LED	5
1L006	6 WATT LED	6
1L007	7 WATT LED	7
1L008	8 WATT LED	8
1L009	9 WATT LED	9
1L010	10 WATT LED	10
1L011	11 WATT LED	11

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
LED Lighting Fixtures		
1L043	43 WATT LED	43
1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46
1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L053	53 WATT LED	53
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L063	63 WATT LED	63
1L070	70 WATT LED	70
1L071	71 WATT LED	71
1L073	73 WATT LED	73
1L075	75 WATT LED	75
1L080	90 WATT LED	90
1L085	85 WATT LED	85
1L090	90 WATT LED	90
1L095	95 WATT LED	95

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[5]

Building Type	Annual Operating Hours
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

[5] 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

Building (or Space) Type	Annual Cooling Hours ($Hours_{cool}$)	Cooling Full Load Hours ($EFLH_{cool}$)	Heating Full Load Hours ($EFLH_{heat}$)
Average – CLC	3,027	1,172	530
Average – NSTAR	3,027	1,172	N/A
Average – National Grid	2,539	935	984
Average – Unitil	1,896	755	1,329
Average – WMECO	1,896	755	1,329
Site Specific - NSTAR	800, 1000-6000 at 1000-hour increments	800, 1000-6000 at 1000-hour increments	N/A

- Average Cooling EFLHs from the 2010 NEEP HVAC Loadshape study.[6] 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.[7]
- Average Heating EFLHs derived from 2010 NEEP HVAC Loadshape study[8] and the Connecticut Program Savings Document for 2011 Program Year. [9]

[6] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.
[7] DNV GL (2014). *Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study*. Prepared for National Grid and Northeast Utilities. August 20, 2014.
[8] Ibid.
[9] 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					

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 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					

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 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					

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 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 - Retrocomissioning, 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

ACRONYM	DESCRIPTION
AC	Air Conditioning
AFUE	Annual Fuel Utilization Efficiency (see the Glossary)
AHU	Air Handling Unit
Btu	British Thermal Unit (see the Glossary)
CF	Coincidence Factor (see the Glossary)
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
COP	Coefficient of Performance (see the Glossary)
DCV	Demand Controlled Ventillation
DHW	Domestic Hot Water
DOER	Department of Energy Resources
DSM	Demand Side Management (see the Glossary)
ECM	Electrically Commutated Motor
EER	Energy Efficiency Ratio (see the Glossary)
EF	Efficiency Factor
EFLH	Equivalent Full Load Hours (see the Glossary)
ES	ENERGY STAR® (see the Glossary)
FCM	Forward Capacity Market
FR	Free-Ridership (see the Glossary)
HE	High-Efficiency
HID	High-Intensity Discharge (a lighting technology)
HP	Horse Power (see the Glossary)
HSPF	Heating Seasonal Performance Factor (see the Glossary)
HVAC	Heating, Ventilating, and Air Conditioning
ISO	Independent System Operator
ISR	In-Service Rate (see the Glossary)
kW	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	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: ALght Lighting HEUBe Behavior HVAC HVAC Ienvl Insulation & Air Sealing CMoDr Motors & Drives JGchp Combined Heat & Power DRefr Refrigeration KSdhw Solar Hot Water EHoWa Hot Water LDmdR Demand Response FComA Compressed Air MPvEl Photovoltaic Panels GProc Process* *For residential measures, "process" is used for products that have low savings, such as consumer electronics, or do not conform to existing end use categories. For commercial and industrial measures, "process" is used for systematic improvements to manufacturing or pump systems, or efficient models of specialty equipment not covered in other end uses.
Energy Efficiency Ratio (EER)	The Energy Efficiency Ratio is a measure of the efficiency of a cooling system at a specified peak, design temperature, or outdoor temperature. In technical terms, EER is the steady-state rate of heat energy removal (i.e. cooling capacity) of a product measured in Btuh output divided by watts input.
ENERGY STAR® (ES)	Brand name for the voluntary energy efficiency labeling initiative sponsored by the U.S. Environmental Protection Agency.
Energy Costing Period	A period of relatively high or low system energy cost, by season. The energy periods defined by ISO-NE are: Summer Peak: 6am–10pm, Monday–Friday (except ISO holidays), June–September

	Summer Off-Peak: Summer hours not included in the summer peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, June–September Winter Peak: 6am–10pm, Monday–Friday (except ISO holidays), January–May and October–December Winter Off-Peak: Winter hours not included in the sinter peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, January–May and October–December.
Equivalent Full Load Hours (EFLH)	The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).
Free Rider	A customer who participates in an energy efficiency program, but would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available.
Free-Ridership Rate	The percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.
Gross kW	Expected demand reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.
Gross kWh	Expected kWh reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.
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, *measure persistence* takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor.
Seasonal Energy Efficiency Ratio (SEER)	A measurement of the efficiency of a central air conditioner over an entire season. In technical terms, SEER is a measure of equipment the total cooling of a central air conditioner or heat pump (in Btu) during the normal cooling season as compared to the total electric energy input (in watt-hours) consumed during the same period.
Seasonal Peak kW	See Summer/Winter Seasonal Peak kW, and Summer/Winter On-Peak Peak kW.
Sector	A system for grouping customers with similar characteristics. For the purpose of this manual, the sectors are Commercial and Industrial (C&I), Small Business, Residential, and Low Income.
Spillover Rate	The percentage of savings attributable to the program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of (a) participants in the program who install additional energy efficient measures outside of the program as a result of hearing about the program and (b) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program.
Summer/Winter On-Peak kW	The average demand reduction during the summer/winter on-peak period. The summer on-peak period is 1pm-5pm on non-holiday weekdays in June, July and August; the winter on-peak period is 5pm-7pm on non-holiday weekdays in December and January.
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.