Massachusetts
Technical Reference Manual

for Estimating Savings from Energy Efficiency Measures

2019 Plan-Year Report Version

May 2020

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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 results in two main versions for each program year:

- the "Plan Version" is filed with the PAs' Three-Year Plan, and
- the "Report Version" includes updates to the "Plan Version" document as needed and is filed with the PAs' Plan-Year/Term Reports, with the final savings algorithms and factors used to report actual savings.

This document is updated over time as needed to both plan for future program savings and to report actual savings.

Key Stakeholders and Responsibilities

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

Stakeholder	Responsibilities
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

Stakeholder	Responsibilities
Department of Energy Resources	▪ Provide one representative to the Coordinating Committee ▪ Assure coordination with PA submissions of program plans and reported savings

Update Cycle

The timeline below shows the main milestones of the update cycle for the 2019-2021 term.

OCTOBER 2018: The 2019-2021 Plan Version TRM is filed with the PAs' Three-Year Plans.

The 2019-2021 Plan Version TRM is filed with the Department with the PAs' three-year energy efficiency plans. The TRM is considered a "planning document" in that it provides the documentation for how the PAs *plan* to count savings for that program year. The TRM is not intended to fully document how the PAs develop their plan estimates for savings.

JANUARY 2019: PAs begin to track savings based on the 2019-2021 TRM

Beginning in January 2019, the PAs will track savings for PY 2019-2021 based on the 2019-2021 – Plan Version TRM.

SPRING 2020: The 2019 Program Year – Report Version TRM will be filed with the 2019 Plan-Year Reports

The 2019 Program Year – Report Version TRM, including any updates relative to the Program Plan version, will be filed with the PAs' Plan-Year Reports. Updates from the Plan Version may include new evaluation results or changes based on working group discussions, and will be clearly identified in the Report Version.

SPRING 2021: The 2020 Program Year – Report Version TRM will be filed with the 2020 Plan-Year Reports

The 2020 Program Year – Report Version TRM, including any updates relative to the Program Plan version, will be filed with the PAs' Plan-Year Reports. Updates from the Plan Version may include new evaluation results or changes based on working group discussions, and will be clearly identified in the Report Version.

SPRING/SUMMER 2022: The 2021 Program Year – Report Version TRM will be filed with the 2019-2021 Term Reports

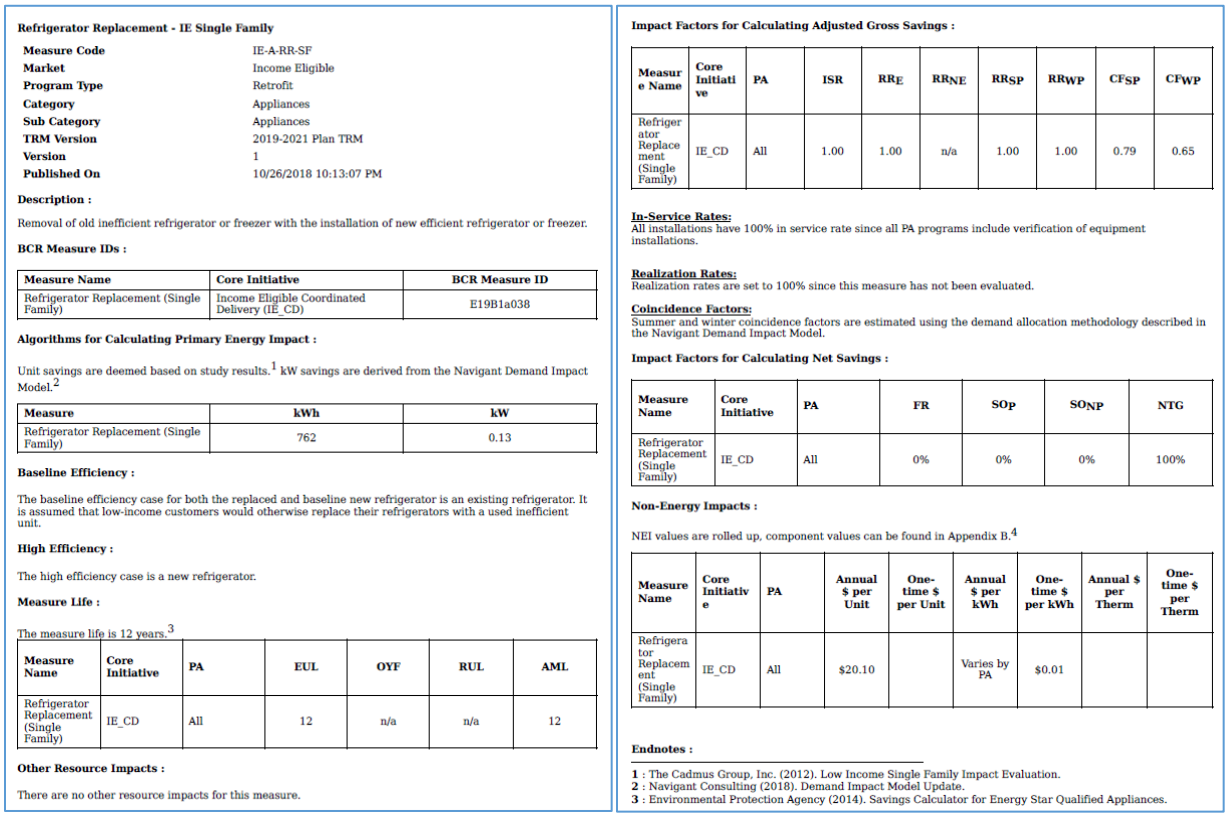
The 2021 Program Year – Report Version TRM, including any updates relative to the Program Plan version, will be filed with the PAs' Term Reports. Updates from the Plan Version may include new evaluation results or changes based on working group discussions, and will be clearly identified in the Report Version.

Measure Characterization Structure

This section describes the common entries or inputs that make up each measure characterization. A formatted template follows the descriptions of each section of the measure characterization. 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:

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 2019-2021 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 to the 2019-2021 Plan Version Technical Reference Manual.

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	=	Realization Rate, electric(kWh)
RR_{NE}	=	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 Name	Core Initiative	BCR Measure ID
Dryer (Energy Star)	Residential Retail (RES_RETAIL)	E19A2c077

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 Navigant Demand Impact Model.[5]

Measure Name	ΔkWh	ΔkW
Dryer (Energy Star)	160	0.04

Baseline Efficiency:

The baseline efficiency case is a new electric resistance dryer that meets the federal standard as of January 1, 2015 which is an Energy Factor (EF) of 3.73 for a vented standard dryer. Different testing procedures were used in setting the federal standard (DOE Test Procedure Appendix D1) and the Energy Star standard (DOE Test Procedure Appendix D2). To enable comparison a baseline CEF

of 3.11 is used. This was derived from ENERGY STAR Version 1.0 Estimated Baseline which multiplies the 2015 federal standard by the average change in electric dryers' assessed CEF between Appendix D1 and Appendix D2: 3.73-(3.73*0.166).

High Efficiency:

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

Measure Life:

The measure life is 12 years.[6]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Dryer (Energy Star)	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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Dryer (Energy Star)	RES_RETAIL	All	0.97	1.00	n/a	1.00	1.00	0.49	0.52

In-Service Rates:

The in-service rate is 97% 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 demand allocation methodology described in the Demand Impact Model.[8]

Impact Factors for Calculating Net Savings:

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

2019

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dryer (Energy Star)	RES_RETAIL	All	0.43	0.00	0.00	0.57

2020

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dryer (Energy Star)	RES_RETAIL	All	0.46	0.00	0.00	0.54

2021

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dryer (Energy Star)	RES_RETAIL	All	0.49	0.00	0.00	0.51

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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Environmental Protection Agency (2018). Savings Calculator for ENERGY STAR Qualified Appliances. Energy_Star_2018_Consumer_Appliance_Calc
7 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
8 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
9 : NMR Group, Inc. (2018). Products Net-to-Gross Report.
2018_NMR_Products_NTG_Consensus_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)	E19A2c075
Dehumidifier Recycling	Residential Retail (RES_RETAIL)	E19A2c076

Algorithms for Calculating Primary Energy Impact:

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

ΔkWh New = Capacity * (0.473/24) * ((1/EffBASE) - (1/EffEE)) * Hours
ΔkWh Recycling = Capacity * (0.473/24) * ((1/EffRETIRE) - (1/EffBASE)) * Hours

Where:
Capacity = Average capacity of dehumidifier in Pints/24 Hours: 35 Pints/Day[1]
EffRETIRE = Average efficiency of model being recycled, in Liters/kWh
EffBASE = Average efficiency of model meeting the federal standard, in Liters/kWh
EffEE = Efficiency of ENERGY STAR® model, in Liters/kWh
Hours = Dehumidifier annual operating hours
0.473 = Conversion factor: 0.473 Liters/Pint
24 = Conversion factor: 24 Hours/Day

Demand savings are derived from the Navigant Demand Impact Model.[2]

Measure Name	ΔkWh	ΔkW
Dehumidifier	167.6	0.04
Dehumidifier Recycling	152.7	0.04

Baseline Efficiency:

The baseline efficiency for rebates on new equipment is a unit meeting the current federal standard.[3] The baseline efficiency for recycling is a unit that is approximately 8 years old, meeting the standard that was in place at the time.[4]

High Efficiency:

The high efficiency case for rebates on new equipment is an ENERGY STAR® unit.[5] The high efficiency case for recycling is a new unit that meets the current federal standard.

Measure Life:

The measure life is 12 years for the dehumidifier and 1/3 of that for dehumidifier recycling.[6]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Dehumidifier	RES_RETAIL	All	12	n/a	n/a	12
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	0.96	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.[7] 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:

Coincidence factors are derived from the Navigant Demand Impact Model.

Impact Factors for Calculating Net Savings:

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

2019

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dehumidifier	RES_RETAIL	All	0.39	0.00	0.00	0.61

2020

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dehumidifier	RES_RETAIL	All	0.42	0.00	0.00	0.58

2021

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

2019-2021

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Dehumidifier Recycling	RES_RETAIL	All	0.50	0.00	0.00	0.50

Non-Energy Impacts:

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

Endnotes:

1 : 35 pints per day was the average capacity for units turned in at the Cape Light Compact's May 2010 event.
2 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Subpart C. Accessed at http://www.ecfr.gov/cgi-bin/text-idx?rgn=div8&node=10:3.0.1.4.18.3.9.2
4 : 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
5 : 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
6 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances. http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

Energy_Star_2018_Consumer_Appliance_Calc
7 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
8 : NMR Group, Inc. (2018). Products Net-to-Gross Consensus Report.
2018_NMR_Products_NTG_Consensus_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 (Retire) Elec DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a016
Early Retirement CW (EE) Elec DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a017
Early Retirement CW (Retire) Gas DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a018
Early Retirement CW (EE) Gas DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a019
Early Retirement CW (Retire) Elec DHW & Gas Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a020
Early Retirement CW (EE) Elec DHW & Gas Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a021
Early Retirement CW (Retire) Oil DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a022
Early Retirement CW (EE) Oil DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a023
Early Retirement CW (Retire) Gas DHW & Gas Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a024
Early Retirement CW (EE) Gas DHW & Gas Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a025
Early Retirement CW (Retire) Propane DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a026

Measure Name	Core Initiative	BCR Measure ID
Early Retirement CW (EE) Propane DHW & Elec Dryer	Residential Coordinated Delivery (RES_CD)	E19A2a027
Early Retirement Clothes Washers (EE) Gas DHW & Elec Dryer (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a019
Early Retirement Clothes Washers (Retire) Gas DHW & Elec Dryer (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a020
Early Retirement Clothes Washers (EE) Elec DHW & Gas Dryer (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a021
Early Retirement Clothes Washers (Retire) Elec DHW & Gas Dryer (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a022
Early Retirement Clothes Washers (EE) Gas DHW & Gas Dryer (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a023
Early Retirement Clothes Washers (Retire) Gas DHW & Gas Dryer (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a024
Early Retirement Clothes Washers (EE) Gas DHW & Elec Dryer (Single Family) (Muni)	Residential Coordinated Delivery (RES_CD)	G19A2a132
Early Retirement Clothes Washers (Retire) Gas DHW & Elec Dryer (Single Family) (Muni)	Residential Coordinated Delivery (RES_CD)	G19A2a133
Early Retirement Clothes Washers (EE) Elec DHW & Gas Dryer (Single Family) (Muni)	Residential Coordinated Delivery (RES_CD)	G19A2a134
Early Retirement Clothes Washers (Retire) Elec DHW & Gas Dryer (Single Family) (Muni)	Residential Coordinated Delivery (RES_CD)	G19A2a135

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
kW Savings are calculated using the Demand Impact Model.[3]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
Early Retirement CW (Retire) Elec DHW & Elec Dryer	342	0.09	0
Early Retirement CW (EE) Elec DHW & Elec Dryer	112	0.03	0
Early Retirement CW (Retire) Gas DHW & Elec Dryer	272	0.07	0.32
Early Retirement CW (EE) Gas DHW & Elec Dryer	12	0	0.46
Early Retirement CW (Retire) Elec DHW & Gas Dryer	125	0.03	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

Measure Name	ΔkWh	ΔkW	ΔMMBtu
Early Retirement CW (Retire) Oil DHW & Elec Dryer	272	0.07	0.32
Early Retirement CW (EE) Oil DHW & Elec Dryer	12	0	0.46
Early Retirement CW (Retire) Propane DHW & Elec Dryer	272	0.07	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	0.49	0.52
Early Retirement CW (EE)	RES_CD	All	1.00	1.00	n/a	1.00	1.00	0.49	0.52

In-Service Rates:

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

Realization Rates:

Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

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)	E19A2c052
Refrigerator Recycling (Combined)	Residential Retail (RES_RETAIL)	E19A2c066

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed and are obtained from the referenced study.[1] kW savings are calculated using the demand impact model.[2]

Measure Name	ΔkWh	ΔkW
Refrigerator Recycling	1027	0.18
Freezer Recycling	769	0.14

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 8 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Refrigerator Recycling	RES_RETAIL	All	8	n/a	n/a	8
Freezer Recycling	RES_RETAIL	All	8	n/a	n/a	8

Other Resource 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 Recycling	RES_RETAIL	All	1.00	0.88	0.88	0.88	0.88	0.79	0.65
Freezer Recycling	RES_RETAIL	All	1.00	0.68	0.68	0.68	0.68	0.79	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.[4]

Coincidence Factors:

Coincidence factors are estimated using the demand allocation methodology described in the Navigant Demand Impact Model.[5]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Refrigerator Recycling	RES_RETAIL	All	0.56	0.00	0.00	0.44
Freezer Recycling	RES_RETAIL	All	0.44	0.00	0.00	0.56

Non-Energy Impacts:

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

Endnotes:

1 : NMR Group, Inc. (2019). Appliance Recycling Report. 2019_NMR_ApplianceRecycleReport
2 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : 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
4 : NMR Group, Inc. (2018). Appliance Recycling Report. 2018_NMR_Appliance_Recycle_Report
5 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : NMR Group, Inc. (2018). Products Net-to-Gross Consensus Report.
2018_NMR_LED_NTG_Consensus

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)	E19A2c072

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on averaged inputs.[1] Capacity savings are calculated assuming that the unit runs continuously, 8760 hours/year.

Measure Name	kWh	kW
Room Air Cleaner	391	0.04

Baseline Efficiency:

The baseline efficiency case is a unit meeting the federal standard.

High Efficiency:

Current E-STAR specification is v1.2 and it requires a minimum of 2.0 CADR/W. The 2018 E-STAR calculator referenced by the TRM assumes an EE level of 3.0 CADR/W. This EE level seems reasonable since the E-STAR database of U.S. products lists ~170 qualified models, with an average efficiency of 3.5 CADR/W.

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.[4]

2019

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Cleaner	RES_RETAIL	All	0.29	0.00	0.00	0.71

2020

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Cleaner	RES_RETAIL	All	0.32	0.00	0.00	0.68

2021

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Room Air Cleaner	RES_RETAIL	All	0.35	0.00	0.00	0.65

Non-Energy Impacts:

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

Endnotes:

1 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances. Energy_Star_2018_Consumer_Appliance_Calc
2 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances. Energy_Star_2018_Consumer_Appliance_Calc
3 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
4 : NMR Group, Inc. (2018). Products Net-to-Gross Report. 2018_NMR_Products_NTG_Consensus_Report

1.6. 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)	E19A2d001
Home Energy Reports	Residential Behavior (RES_BEHVR)	G19A2d001

Algorithms for Calculating Primary Energy Impact:

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.

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	RES_BEHVR	Eversource	Elec	1.00	1.04	n/a	1.04	1.04	0.55	0.85
Home Energy Reports	RES_BEHVR	National Grid	Elec	1.00	0.95	n/a	0.95	0.95	0.55	0.85
Home Energy Reports	RES_BEHVR	CLC	Elec	1.00	1.04	n/a	1.00	1.00	0.55	0.85
Home Energy Reports	RES_BEHVR	Unitil	Elec	1.00	1.00	n/a	1.00	1.00	0.55	0.85
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	RES_BEHVR	Eversource	Gas	1.00	n/a	0.98	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:

Realization rates are based on evaluation results.[1]

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described the Demand Impact Model.[2]

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 : Navigant Consulting and Illume Advising (2015). Behavior Program Evaluation Opower Results. Navigant_Illume_2014_Behavior_Program_Impact_Evaluation
2 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

1.7. Behavior - Temperature Optimization

Measure Code	RES-BEH-TEMPOPT
Market	Residential
Program Type	Behavior
Category	Other

Measure Description:

Temperature optimization is a passive algorithmic optimization of wi-fi thermostat setpoints to reduce customers' annual heating and cooling consumption. Qualified customers can opt in to the program and have their thermostat setpoints optimized to maintain their thermal comfort while reducing their energy consumption.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Temperature Optimization, Summer	Residential Behavior (RES_BEHVR)	E19A2d002
Temperature Optimization, Winter, Electric	Residential Behavior (RES_BEHVR)	E19A2d005
Temperature Optimization, Winter, Oil	Residential Behavior (RES_BEHVR)	E19A2d003
Temperature Optimization, Winter, Propane	Residential Behavior (RES_BEHVR)	E19A2d004
Temperature Optimization, Winter, Gas	Residential Behavior (RES_BEHVR)	G19A2d002

Algorithms for Calculating Primary Energy Impact:

The savings are custom calculations by the vendor, based on customer HVAC usage during the summer and winter, separately.

Measure Name	Core Initiative	kW-per-kWh
Temperature Optimization, Summer	RES_BEHVR	0.00166
Temperature Optimization, Winter, Electric	RES_BEHVR	0.00044
Temperature Optimization, Winter, Oil	RES_BEHVR	0.00064
Temperature Optimization, Winter, Propane	RES_BEHVR	0.00064
Temperature Optimization, Winter, Gas	RES_BEHVR	0.00064

Baseline Efficiency:

The baseline efficiency is a customer not participating in the temperature optimization program.

High Efficiency:

The high efficiency is a customer participating in the temperature optimization program.

Measure Life:

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Temperature Optimization (Summer)	RES_BEHVR	All	1	n/a	n/a	1
Temperature Optimization (Winter)	RES_BEHVR	All	1	n/a	n/a	1

Other Resource Impacts:

The vendor custom calculates electric, oil, propane, and natural gas savings 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}
Temperature Optimization, Summer	RES_BEHVR	All	1.00	0.99	1.00	0.99	0.99	0.29	0.00
Temperature Optimization, Winter, Electric	RES_BEHVR	All	1.00	1.00	0.98	1.00	1.00	0.00	0.62
Temperature Optimization, Winter, Oil	RES_BEHVR	All	1.00	1.00	0.98	1.00	1.00	0.00	0.45
Temperature Optimization, Winter, Propane	RES_BEHVR	All	1.00	1.00	0.98	1.00	1.00	0.00	0.45
Temperature Optimization, Winter, Gas	RES_BEHVR	All	1.00	0.98	0.97	0.98	0.98	0.00	0.45

In-Service Rates:

All installations have 100% in-service rate, as the program tracks all participating customers.

Realization Rates:

Summer and winter realization rates are based on evaluation results.

Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology of the residential Demand Impact Model.[2]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Temperature Optimization (Summer)	RES_BEHVR	All	0.00	0.00	0.00	1.00
Temperature Optimization (Winter)	RES_BEHVR	All	0.00	0.00	0.00	1.00

Non-Energy Impacts:

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

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)	E19A2a028
Air Sealing, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a029
Air Sealing, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a030
Air Sealing, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a031
Air Sealing, Electric (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a105
Air Sealing, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a106
Air Sealing, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a107
Air Sealing, Electric (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a193
Air Sealing, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a194
Air Sealing, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a195
Air Sealing, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a001
Air Sealing, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a046
Air Sealing, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a079
Air Sealing, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a293

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 initiative. 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 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[2]

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 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 baseline/pre-retrofit ACH =0.4.

Measure Life:

The measure life is 15 years.[4]

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:

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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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[5] while High Rise is based on Multifamily evaluation results.[6]

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.[7]

Impact Factors for Calculating Net Savings:

Net-to-gross factors for Single Family[8], Attached Low Rise[9] and High Rise[10] are based on evaluation results.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Air Sealing, Electric (Single Family)	RES_CD	All	0.08	0.08	0.28	1.28
Air Sealing, Gas (Single Family)	RES_CD	All	0.08	0.08	0.28	1.28
Air Sealing, Oil (Single Family)	RES_CD	All	0.08	0.08	0.28	1.28
Air Sealing, Other (Single Family)	RES_CD	All	0.08	0.08	0.28	1.28
Air Sealing, Electric (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Gas (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Oil (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Other (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Electric (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Oil (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Other (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Air Sealing, Gas (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.[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
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
2 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : The Cadmus Group, Inc. (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis. CADMUS_2012_Multifamily_Impacts_Analysis_Report
5 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.
2018_Navigant_HES_Impact_Evaluation
6 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation
2018_Navigant_Multifamily_Program_Impact_Evaluation
7 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
8 : The Cadmus Group (2012). Massachusetts 2011 Residential Retrofit and Low income Net-to-Gross Evaluation. CADMUS_2012_HES Net-to-Gross Impact Evaluation
9 : Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review
10 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
11 : 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

1.9. 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)	E19A2a032
Insulation, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a033
Insulation, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a034
Insulation, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a035
Insulation, Electric (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a108
Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a109
Insulation, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a110
Insulation, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a111
Insulation, Electric (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a196
Insulation, Central AC in Electrically-Heated Unit (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a197
Insulation, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a198
Insulation, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a199
Insulation, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a002
Insulation, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a047
Insulation, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a080
Insulation, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a294

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)
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)
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 (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	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:

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	0.34	0.21
Insulation, Oil (Single Family)	RES_CD	National Grid	1.00	1.00	0.77	1.00	1.00	0.34	0.21
Insulation, Other (Single Family)	RES_CD	National Grid	1.00	1.00	1.00	1.00	1.00	0.34	0.21
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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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	0.34	0.21
Insulation, Other (Attached Low Rise)	RES_CD	National Grid	1.00	1.00	1.00	1.00	1.00	0.34	0.21
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	0.34	0.21
Insulation, Oil (Single Family)	RES_CD	Eversource	1.00	1.00	0.77	1.00	1.00	0.34	0.21
Insulation, Other (Single Family)	RES_CD	Eversource	1.00	1.00	1.00	1.00	1.00	0.34	0.21
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	0.35	0.00
Insulation, Gas (Attached Low Rise)	RES_CD	Eversource	1.00	1.00	0.75	1.00	1.00	0.34	0.21
Insulation, Oil (Attached Low Rise)	RES_CD	Eversource	1.00	1.00	0.77	1.00	1.00	0.34	0.21
Insulation, Other (Attached Low Rise)	RES_CD	Eversource	1.00	1.00	1.00	1.00	1.00	0.34	0.21
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	0.34	0.21
Insulation, Oil (Single Family)	RES_CD	Unitil	1.00	1.00	0.79	1.00	1.00	0.34	0.21
Insulation, Other (Single Family)	RES_CD	Unitil	1.00	1.00	0.89	1.00	1.00	0.34	0.21
Insulation, Electric (Attached Low Rise)	RES_CD	Unitil	1.00	0.54	1.00	0.54	0.54	0.00	0.43

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation, Central AC in Electrically-Heated Unit (Attached Low Rise)	RES_CD	Unitil	1.00	0.54	1.00	0.54	0.54	0.35	0.00
Insulation, Gas (Attached Low Rise)	RES_CD	Unitil	1.00	1.00	0.68	1.00	1.00	0.34	0.21
Insulation, Oil (Attached Low Rise)	RES_CD	Unitil	1.00	1.00	0.79	1.00	1.00	0.34	0.21
Insulation, Other (Attached Low Rise)	RES_CD	Unitil	1.00	1.00	0.89	1.00	1.00	0.34	0.21
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	0.34	0.21
Insulation, Oil (Single Family)	RES_CD	CLC	1.00	1.00	0.79	1.00	1.00	0.34	0.21
Insulation, Other (Single Family)	RES_CD	CLC	1.00	1.00	0.89	1.00	1.00	0.34	0.21
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	0.35	0.00
Insulation, Gas (Attached Low Rise)	RES_CD	CLC	1.00	1.00	0.68	1.00	1.00	0.34	0.21
Insulation, Oil (Attached Low Rise)	RES_CD	CLC	1.00	1.00	0.79	1.00	1.00	0.34	0.21
Insulation, Other (Attached Low Rise)	RES_CD	CLC	1.00	1.00	0.89	1.00	1.00	0.34	0.21
Insulation, Gas (Single Family)	RES_CD	Berkshire	1.00	1.00	0.83	1.00	1.00	0.34	0.21
Insulation, Gas (Attached Low Rise)	RES_CD	Berkshire	1.00	1.00	0.83	1.00	1.00	0.34	0.21
Insulation, Gas (Single Family)	RES_CD	Columbia	1.00	1.00	0.68	1.00	1.00	0.34	0.21

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation, Gas (Attached Low Rise)	RES_CD	Columbia	1.00	1.00	0.68	1.00	1.00	0.34	0.21
Insulation, Gas (Single Family)	RES_CD	Liberty	1.00	1.00	0.68	1.00	1.00	0.34	0.21
Insulation, Gas (Attached Low Rise)	RES_CD	Liberty	1.00	1.00	0.68	1.00	1.00	0.34	0.21
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	0.35	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 demand allocation methodology described in the Demand Impact Model.[8]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results for single family[9], attached low rise[10], and high rise.[11]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Insulation (Single Family)	RES_CD	All	0.25	0.2	0.28	1.23
Insulation (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Insulation (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.[12]

Measure Name	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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
9 : The Cadmus Group (2012). Massachusetts 2011 Residential and Low Income Net-to-Gross Evaluation. CADMUS_2012_HES Net-to-Gross Impact Evaluation
10 : Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review
11 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
12 : 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

1.10. 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
Process - Custom	Residential Coordinated Delivery (RES_CD)	E19A2a251
CHP	Residential Coordinated Delivery (RES_CD)	E19A2a252
Other - Custom	Residential Coordinated Delivery (RES_CD)	E19A2a253
HVAC- Custom	Residential Coordinated Delivery (RES_CD)	E19A2a272
Water Heating - Custom	Residential Coordinated Delivery (RES_CD)	E19A2a273
Heating, Gas - Custom (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a094
Process, Gas - Custom (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a095
Water Heating, Gas - Custom (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a096

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
HVAC- Custom	RES_CD	Statewide	custom	n/a	n/a	custom
Water Heating - Custom	RES_CD	Statewide	custom	n/a	n/a	custom
Process - Custom	RES_CD	Statewide	custom	n/a	n/a	custom
CHP	RES_CD	Statewide	custom	n/a	n/a	custom
Other - Custom	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}
HVAC- Custom	RES_CD	All	1.00	0.86	0.86	0.86	0.86	custom	custom
Water Heating - Custom	RES_CD	All	1.00	0.86	0.86	0.86	0.86	custom	custom
Process - Custom	RES_CD	All	1.00	0.86	0.86	0.86	0.86	custom	custom
CHP	RES_CD	All	1.00	custom	custom	custom	custom	custom	custom
Other - Custom	RES_CD	All	1.00	0.86	0.86	0.86	0.86	custom	custom
Heating, Gas - Custom (High Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Process, Gas - Custom (High Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Water Heating, Gas - Custom (High Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	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:

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 factors are based on evaluation results.[2]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
All Measures - Custom	RES_CD	Statewide	0.21	0.13	0.17	1.09

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
HVAC-Custom	RES_CD	Statewide			$0.02			
Water Heating - Custom	RES_CD	Statewide						
Process - Custom	RES_CD	Statewide			$0.06			
CHP	RES_CD	Statewide			-$0.01			
Other - Custom	RES_CD	Statewide						
Heating, Gas - Custom (High Rise)	RES_CD	Statewide						
Process, Gas - Custom (High Rise)	RES_CD	Statewide						
Water Heating, Gas - Custom (High Rise)	RES_CD	Statewide						

Endnotes:

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

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

1.11. 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)	E19A2e001
Storage System and Performance, Summer	Residential Active Demand Reduction (RES_ADR)	E19A2e002
Storage Daily Dispatch, Summer	Residential Active Demand Reduction (RES_ADR)	E19A2e003
Storage Targeted Dispatch, Winter	Residential Active Demand Reduction (RES_ADR)	E19A2e004
EV Load Management, Summer	Residential Active Demand Reduction (RES_ADR)	E19A2e005
EV Load Management, Winter	Residential Active Demand Reduction (RES_ADR)	E19A2e006
Behavioral DR	Residential Active Demand Reduction (RES_ADR)	E19A2e007
Storage System and Performance, Winter	Residential Active Demand Reduction (RES_ADR)	E19A2e008

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 Storage Daily Dispatch, unit savings are deemed based on study results.[1]

PA	kW Savings per Battery*
National Grid	5.5
Unitil	1.3

* 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.[2]

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.[3]

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:

Statewide Active Demand Reduction offerings are new in 2019; 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, the realization rate is based on hourly load adjustment factors calculated by independent evaluators based on a comparison of evaluated and reported demand reduction.[4]

For Storage Daily Dispatch, no evaluated realization rate is available; deemed per device savings should be used instead.

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
Behavioral DR	RES_ADR	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Storage System and Performance, discharge (savings) Summer	RES_ADR	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Storage System and Performance, charge (consumption) Summer	RES_ADR	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Storage System and Performance, discharge (savings) Winter	RES_ADR	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Storage System and Performance, charge (consumption) Winter	RES_ADR	All	1.00	1.00	1.00	1.00	1.00	0.00	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

*For Direct Load Control, evaluated results are used to calculate benefits, and therefore a separate realization rate is not used. 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. In practice, the hourly load adjustment factors are used to adjust vendor estimates of 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.

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
2 : Guidehouse (2020). 2019 Residential Wi-Fi Thermostat Direct Load Control Offering Evaluation. 2019 _Guidehouse_Residential_Wi-Fi_Thermostat_DLC
3 : Guidehouse (2020). 2019 Residential Energy Storage Demand Response Demonstration Evaluation: Summer Season. 2020_Guidehouse_Residential_Energy_Storage_Demand_Response
4 : Guidehouse (2020). 2019 Residential Wi-Fi Thermostat Direct Load Control Offering Evaluation. 2019 _Guidehouse_Residential_Wi-Fi_Thermostat_DLC

1.12. HVAC - Air Source Central Heat Pump

Measure Code	RES-HVAC-ASHP
Market	Residential
Program Type	Early Retirement, Replace on Burnout
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
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	Residential Coordinated Delivery (RES_CD)	E19A2a092
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	Residential Retail (RES_RETAIL)	E19A2c003

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:

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

Where:
Unit = Installation of heat pump system
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 Capacity (tons)[2]	Average SEER[3]	Average HSPF[4]	Hours[5]	ΔkWh	Annual Max Demand Factor[6]	ΔkW
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	Electric	2.8	19.1	10.6	419 (cool) 1,200 (heat)	1,301.1	0.001594 (cool) 0.000438 (heat)	0.502

Baseline Efficiency:

For replace on failure, the baseline is a code-compliant 2.8-ton, 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 2.8-ton, SEER 10, HSPF 7 heat pump unit. For early retirement, over the life of the new heat pump, the baseline is a code-compliant 2.8-ton, SEER 14, HSPF 8.2 heat pump unit.

High Efficiency:

For replace on failure, the high efficiency case is a 2.8-ton, SEER 19.1, HSPF 10.6 heat pump 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 heat pump unit, the high efficiency case is a code-compliant 2.8-ton, 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 2.8-ton, SEER 19.1, HSPF 10.6 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
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	RES_CD, RES_RETAIL	All	18	n/a	6	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}
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	RES_CD, RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.35	0.533

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.[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
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	RES_CD, RES_RETAIL	All	0.23	0.001	0.002	0.77

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
Heat Pump, SEER 18, Replacing Existing EUL Heat Pump	RES_CD, RES_RETAIL	All	$8.11	$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 in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations
2 : Average capacity (tons) of heat pump units rebated in the full calendar year preceding the year in which this eTRM is published.
3 : Average SEER of heat pump units rebated in the full calendar year preceding the year in which this eTRM is published.
4 : Average HSPF of heat pump units 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). Demand Impact Model Update. Value for Central Air Conditioner/Heat Pump (Cooling) and Ductless Mini-Split Heat Pumps (Heating) 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : MA PAs (2018). 2019-2021 Electric HVAC Calculations Workbook. Measure life reflects a blend of replace on failure and early replacement. MA_PAs_2019-2021 Electric_HVAC_Calculations
8 : MA PAs (2018). 2019-2021 Electric HVAC Calculations Workbook. Values reflect a blend of replace on failure and early replacement. Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update. MA_PAs_2019-2021 Electric_HVAC_Calculations
9 : MA PAs (2018). 2019-2021 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 (2018). 2019-2021 Electric HVAC Calculations Workbook. MA_PAs_2019-2021 Electric_HVAC_Calculations
10 : MA PAs (2018). 2019-2021 Electric HVAC Calculations Workbook. MA_PAs_2019-2021 Electric_HVAC_Calculations

1.13. 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
Boiler Reset Control, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a039
Boiler Reset Control, Oil	Residential Coordinated Delivery (RES_CD)	E19A2a014
Boiler Reset Control, Other	Residential Coordinated Delivery (RES_CD)	E19A2a015
Boiler Reset Control, Gas	Residential Retail (RES_RETAIL)	G19A2c021
Boiler Reset Control, Gas - Midstream	Residential Retail (RES_RETAIL)	E19A2c276
Boiler Reset Control, Oil - Midstream	Residential Retail (RES_RETAIL)	E19A2c277
Boiler Reset Control, Other - Midstream	Residential Retail (RES_RETAIL)	E19A2c278
Boiler Reset Control, Gas - Midstream	Residential Retail (RES_RETAIL)	G19A2c048

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	ΔMMBtu
Boiler Reset Control, Gas	5.1
Boiler Reset Control, Oil	5.2
Boiler Reset Control, Other	5.1

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, Gas	RES_CD	All	15	n/a	n/a	15
Boiler Reset Control, Oil	RES_CD	All	15	n/a	n/a	15
Boiler Reset Control, Other	RES_CD	All	15	n/a	n/a	15
Boiler Reset Control, 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}
Boiler Reset Control, Gas	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Boiler Reset Control, Oil	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Boiler Reset Control, Other	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

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, Gas	RES_CD	All	0.00	0.00	0.00	1.00
Boiler Reset Control, Oil	RES_CD	All	0.00	0.00	0.00	1.00
Boiler Reset Control, Other	RES_CD	All	0.00	0.00	0.00	1.00
Boiler Reset Control, Gas	RES_RETAIL	All	0.00	0.00	0.00	1.00
Boiler Reset Control, Gas - Midstream	RES_RETAIL	All	0.21	0.00	0.00	0.79
Boiler Reset Control, Oil - Midstream	RES_RETAIL	All	0.21	0.00	0.00	0.79
Boiler Reset Control, Other - Midstream	RES_RETAIL	All	0.21	0.00	0.00	0.79
Boiler Reset Control, Gas - Midstream	RES_RETAIL	All	0.21	0.00	0.00	0.79

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 : ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE.
ACEEE_2006_Emerging_Technologies_Report_Advanced_Boiler_Controls

1.14. 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 Coordinated Delivery (RES_CD)	E19A2a004
Central Air QIV	Residential Retail (RES_RETAIL)	E19A2c104

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the following algorithms and assumptions:[1]

ΔkWh = Tons × 12 kBtu/hr/Ton × (1/SEER) × Hours x 5%
ΔkW = ΔkWh × 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	2.67	16.7	419	40.3	0.001594	0.064

Baseline Efficiency:

The baseline efficiency case is a new central air conditioning system (2.67-ton and SEER 16.7), based on the average capacity and efficiency level of units rebated in the previous calendar year (2019), 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_{NE}**	RRSP	RRWP	CFSP	CFWP
Central Air QIV	RES_CD,	All	1.00	1.00	1.00	1.00	1.00	0.346	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.[8]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Central Air QIV	RES_CD, 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.

Measure Name	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' 2019 Electric Heating and Cooling Savings Workbook (2019). 2019_MA_PAs_Electric_HVAC_Calculations
2 : Massachusetts Common Assumptions.
3 : Average capacity (tons) of central air conditioning units rebated in the full calendar year preceding the year in which this eTRM is published.
4 : Average SEER of central air conditioning units 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.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Navigant Consulting (2018). Demand Impact Model Update. Value for Central Air Conditioner/Heat Pump (Cooling). 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
8 : Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling))
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

1.15. HVAC - Central Air Conditioning

Measure Code	RES-HVAC-CAC
Market	Residential
Program Type	Early Retirement, Replace on Burnout
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 Coordinated Delivery (RES_CD)	E19A2a088
Central Air	Residential Retail (RES_RETAIL)	E19A2c001

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:

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

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)

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

Savings for Residential Central Air Conditioners[1]

Measure Name	Energy Type	Average Capacity (tons)[2]	Average SEER[3]	Hours[4]	ΔkWh	Annual Max Demand Factor[5]	ΔkW
Central Air (Blended Savings, 60.5% Replace on Failure and 39.5% Early Retirement)	Electric	2.7	16.5	419	351.8	0.001594	0.561

Baseline Efficiency:

For replace on failure, the baseline is a code-compliant 2.7-ton, SEER 13 central air-conditioning unit.

For early retirement, over the remaining life of the existing air conditioning unit, the baseline is an existing inefficient 2.7-ton, SEER 10 central air-conditioning unit. For early retirement, over the life of the new air conditioner, the baseline is a code-compliant 2.7-ton, SEER 13 central air-conditioning unit.

High Efficiency:

For replace on failure, the high efficiency case is a 2.7-ton, SEER 16.5 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 a code-compliant 2.7-ton, SEER 13 central air-conditioning unit. For early retirement, over the life of the new air conditioner, the high efficiency case is a 2.7-ton, SEER 16.5 central air-conditioning unit.

Measure Life:

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 14 years.

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Central Air	RES_CD, RES_RETAIL	All	18	N/A	6	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}
Central Air	RES_CD, RES_RETAIL	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 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.[7]

Impact Factors for Calculating Net Savings:

NTG factors reflect a blend[8] of replace on failure NTG factors[9] and early retirement NTG factors[10].

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Central Air	RES_CD, RES_RETAIL	All	0.56	0.12	0.06	0.62

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.[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
Central Air	RES_CD RES RETAIL	All	$8.98					

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 in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations
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). Demand Impact Model Update. Value for Central Air Conditioner/Heat Pump (Cooling). 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations

7 : Values reflect a blend of replace on failure and early replacement. Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling)). The calculation of coincidence factors can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018).
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

8 : The calculation of the blended NTG factors can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations

9 : NMR Group (2018). Massachusetts Residential HVAC NTG and Market Effects Study
2018_NMR_Res_HVAC_NTG_ME_Study

10 : Navigant Consulting (2018). Heating and Cooling Early Retirement Net-to-Gross
2018_Navigant_Early_Retirement_HVAC_NTG

11 : The calculation of the blended NEIs can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations

1.16. HVAC - Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil/Propane

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, Propane	Residential Coordinated Delivery (RES_CD)	E19A2a263
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	Residential Coordinated Delivery (RES_CD)	E19A2a264
Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane	Residential Retail (RES_RETAIL)	E19A2c271
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	Residential Retail (RES_RETAIL)	E19A2c272

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, using the following key assumptions[1]:

Average Annual Home Heating load = 68.4 MMBTUs[2]
Electric Resistance Switchover Temperature = 5°F
Capacity of new Heat Pump = 4 Tons
Average Annual Cooling Load: 13.1 MMBtus
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane	86.7	-8.15	-6,278
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	86.7	-8.15	-6,278

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 Room/Window A/C 8 EER, Central A/C 10 SEER/ 8.5 EER.[6]

High Efficiency:

The high efficiency case is a new 18 SEER/9.6 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
Central Ducted Heat Pump Fully Displacing Existing Furnace	RES_CD 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 Fully Displacing Existing Furnace	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.34	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	Core Initiative	PA	FR[8]	SO_P	SO_{NP}	NTG
Central Ducted Heat Pump Fully Displacing Existing Furnace	RES_CD RES_RETAIL	All	0.10	0.00	0.00	0.90

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
3 : Navigant Consulting (2018). Baseline Study Saturation Results 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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
8 : Agreed upon value with EEAC consultants

1.17. HVAC - Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil/Propane

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, Propane	Residential Coordinated Delivery (RES_CD)	E19A2a256
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	Residential Coordinated Delivery (RES_CD)	E19A2a258
Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	Residential Retail (RES_RETAIL)	E19A2c265
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	Residential Retail (RES_RETAIL)	E19A2c266

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, using the following key assumptions:[1]

Average annual home heating load = 68.4 MMBTUs [2]
Switchover temperature = 30°F (oil) or 15°F (propane)
Capacity of new heat pump = 2.5 Tons
Average annual home cooling load: 16.1 MMBTUs
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Δ MMBtus, Oil or Propane	ΔkW	ΔkWh
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	42.1	-1.77	-3,814
Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	76.5	-2.26	-6,378

Baseline Efficiency:

For oil and propane, the baseline is an existing inefficient furnace at 78% AFUE.
For existing air conditioning, the baseline is 8 EER (room/window) or 10 SEER/ 8.5 EER (central).

High Efficiency:

The high efficiency case is a new 2.5-ton 18 SEER/9.6 HSPF ducted central heat pump.

Measure Life:

The measure life is based on evaluation results.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Central Ducted Heat Pump Partially Displacing Existing Furnace	RES_CD 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_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	-0.12	0.21
Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	-0.09	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 PA-calculated to reflect the blend of heating and cooling provided by heat pumps.[5]

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	RES_CD RES_RETAIL	All	0.10	0.00	0.00	0.90[6]

Non-Energy Impacts:

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

Endnotes:

1 : Navigant Consulting (2018). Energy Optimization Stud 2018_Navigant_Energy_Optimization
2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : 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
5 : Values reflect a blend of heating and cooling, as calculated from the estimated heating and cooling ΔkWh values and the load shapes obtained from Navigant Consulting (2018), Demand Impact Model Update (for Ductless Mini Split Heat Pumps (heating) and Central Air Conditioner/Heat Pump (Cooling)). 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Per agreement with EEAC consultants.

1.18. HVAC - Combo Condensing Boiler/Water Heater

Measure Code	RES-HVAC-CCBWH
Market	Residential
Program Type	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 (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a038
Heating System, Combo Condensing Boiler/Water Heater, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a073
Combo Condensing Boiler/Water Heater 95%, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a085
Combo Condensing Boiler/Water Heater 95%, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a173
Heating System, Combo Condensing Boiler/Water Heater, Gas	Residential Retail (RES_RETAIL)	G19A2c008
Combo Condensing Boiler/Water Heater 95%, Other	Residential Retail (RES_RETAIL)	E19A2c021

Algorithms for Calculating Primary Energy Impact:

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] [4]

Measure Name	ΔMMBtu
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	12.8
Combo Condensing Boiler/Water Heater 95%, Other	12.8

Baseline Efficiency:

The baseline efficiency case is an 82% AFUE rated boiler (79.3% AFUE actual) with a 0.6 EF water heater. The ER baseline is an 80% AFUE rated boiler (77.4% AFUE actual) with either an indirect water heater or with a 0.55 EF water heater. 80% were indirect and 20% were storage water heaters.

High Efficiency:

The high efficiency case is either an integrated water heater/boiler unit with a 90% AFUE condensing boiler (actual was 87.2% and a 0.9 EF water heater (actual was 87.2%) or a 95% AFUE condensing boiler (actual was 89.4%) and a 0.95 EF water heater (actual was 89.4%).

Measure Life:

The measure life is 19 years.[5] [6]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_CD	All	19	n/a	n/a	19
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_RETAIL	All	19	n/a	n/a	19
Combo Condensing Boiler/Water Heater 95%, Other	RES_CD	All	19	n/a	n/a	19
Combo Condensing Boiler/Water Heater 95%, Other	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}
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_CD	All	1.00	1.00	n/a	n/a	n/a	n/a	n/a
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_RETAIL	All	1.00	1.00	n/a	n/a	n/a	n/a	n/a
Combo Condensing Boiler/Water Heater 95%, Other	RES_CD	All	1.00	1.00	n/a	n/a	n/a	n/a	n/a
Combo Condensing Boiler/Water Heater 95%, Other	RES_RETAIL	All	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 are calculated.[7] [8]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_CD	All	0.34	0.08	0.00	0.74
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_RETAIL	All	0.34	0.08	0.00	0.74
Combo Condensing Boiler/Water Heater 95%, Other	RES_CD	All	0.34	0.08	0.00	0.74
Combo Condensing Boiler/Water Heater 95%, Other	RES_RETAIL	All	0.34	0.08	0.00	0.74

Non-Energy Impacts:

NEIs are calculated.[9] [10] 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 Boiler/Water Heater, Gas 95%	RES_CD	All	$75.52					
Heating System, Combo Condensing Boiler/Water Heater, Gas 95%	RES_RETAIL	All	$75.52					

Measure Name	Core Initiative	PA	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Combo Condensing Boiler/Water Heater 95%, Other	RES_CD	All	$75.52					
Combo Condensing Boiler/Water Heater 95%, Other	RES_RETAIL	All	$75.52					

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 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook
MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
4 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook.
MA_PAs_2019_2021_Oil_Propane_Calculations
5 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook
MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
6 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook
MA_PAs_2019_2021_Oil_Propane_Calculations
7 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook.
MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
8 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook
MA_PAs_2019_2021_Oil_Propane_Calculations
9 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook
MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
10 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook
MA_PAs_2019_2021_Oil_Propane_Calculations

1.19. HVAC - Combo Furnace/Water Heater

Measure Code	RES-HVAC-CFWH
Market	Residential
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 (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a129
Heating System, Combo Condensing Furnace/Water Heater, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a130
Heating System, Combo Condensing Furnace/Water Heater, Gas	Residential Retail (RES_RETAIL)	G19A2c045

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[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 18 years.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System, Combo Condensing Furnace/Water Heater, Gas 97%	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}
Heating System, Combo Condensing Furnace/Water Heater, Gas	RES_CD 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	RES_CD RES_RETAIL	All	0.08	0.00	0.00	0.92

Non-Energy Impacts:

Non-Energy Impacts are calculated.[6] 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	RES_CD RES_RETAIL	All	$30.84	$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 : Environmental Protection Agency (2009). Lifecycle Cost Estimate for Energy Star Furnace.
EPA_2009_Lifecycle_Cost_Estimate_for_ENERGY_STAR_Furnace
5 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook
MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
6 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook
MA_PAs_2019_2021_Gas_HVAC_WH_Calculations

1.20. 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)	E19A2a290
Wi-Fi Thermostat, AC Only (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a064
Wi-Fi Thermostat, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a065
Wi-Fi Thermostat, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a067
Wi-Fi Thermostat, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a069
Wi-Fi Thermostat, Electric (Attached Low-Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a289
Wi-Fi Thermostat, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a148
Wi-Fi Thermostat, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a149
Wi-Fi Thermostat, AC Only (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a235
Wi-Fi Thermostat, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a236
Wi-Fi Thermostat, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a237

Measure Name	Core Initiative	BCR Measure ID
Wi-Fi Thermostat, AC Only (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a268
Wi-Fi Thermostat, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a269
Wi-Fi Thermostat, Electric	Residential Retail (RES_RETAIL)	E19A2c275
Wi-Fi Thermostat, AC Only	Residential Retail (RES_RETAIL)	E19A2c058
Wi-Fi Thermostat, Gas	Residential Retail (RES_RETAIL)	E19A2c060
Wi-Fi Thermostat, Oil	Residential Retail (RES_RETAIL)	E19A2c062
Wi-Fi Thermostat, Other	Residential Retail (RES_RETAIL)	E19A2c064
Wi-Fi Thermostat (instant rebate)	Residential Retail (RES_RETAIL)	E19A2c284
Wi-Fi Thermostat, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a013
Wi-Fi Thermostat, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a058
Wi-Fi Thermostat, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a092
Wi-Fi Thermostat, Gas	Residential Retail (RES_RETAIL)	G19A2c030

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1] 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	ΔkW[2]	Δ MMBtu
Wi-Fi Thermostat, Electric (Single Family)	RES_CD	64	0.05	
Wi-Fi Thermostat, AC Only (Single Family)	RES_CD	64	0.10	
Wi-Fi Thermostat, Gas (Single Family)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Oil (Single Family)	RES_CD	18	0.03	3.11

Measure Name	Core Initiative	ΔkWh	ΔkW[2]	Δ MMBtu
Wi-Fi Thermostat, Other (Single Family)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Electric (Attached Low Rise)	RES_CD	64	0.05	
Wi-Fi Thermostat, AC Only (Attached Low Rise)	RES_CD	64	0.10	
Wi-Fi Thermostat, Gas (Attached Low Rise)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Oil (Attached Low Rise)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Other (Attached Low Rise)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, AC Only (High Rise)	RES_CD	64	0.10	
Wi-Fi Thermostat, Oil (High Rise)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Other (High Rise)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Gas (High Rise)	RES_CD	18	0.03	3.11
Wi-Fi Thermostat, Electric	RES_RETAIL	64	0.05	
Wi-Fi Thermostat, AC Only	RES_RETAIL	64	0.10	
Wi-Fi Thermostat, Gas	RES_RETAIL	18	0.03	3.11
Wi-Fi Thermostat, Oil	RES_RETAIL	18	0.03	3.11
Wi-Fi Thermostat, Other	RES_RETAIL	18	0.03	3.11
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.[3]

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	1.00	1.00	1.00	1.00	1.00	0.34	0.20
Wi-Fi Thermostat, AC Only (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Gas (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Oil (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Other (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Electric (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.20
Wi-Fi Thermostat, AC Only (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Gas (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Oil (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Other (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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:

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 demand allocation methodology described the Demand Impact Model.[4]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Wi-Fi Thermostat (Single Family)	RES_CD	All	0.00	0.00	0.00	1.00
Wi-Fi Thermostat (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Wi-Fi Thermostat (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Wi-Fi Thermostat	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. 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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

1.21. HVAC - DMSHP Integrated Controls Retrofit, Oil/Propane

Measure Code	RES-HVAC-DMSHPIC
Market	Residential
Program Type	Retrofit
Category	Heating Ventilation and Air Conditioning

Measure Description:

Installation of integrated controls on an existing ductless minisplit heat pump.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
DMSHP Integrated Controls Retrofit, Propane	Residential Coordinated Delivery (RES_CD)	E19A2a262
DMSHP Integrated Controls Retrofit, Oil	Residential Coordinated Delivery (RES_CD)	E19A2a261

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on calculations provided by evaluation consultants using the following assumptions[1]:

Average home heating load = 76.7 MMBTUs [2]
Switchover temperature = 5 Degrees
Tonnage of new heat pump = 4 Tons
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
DMSHP Integrated Controls Retrofit, Propane	84.7	-2.37	-7,564
DMSHP Integrated Controls Retrofit, Oil	49.7	-2.04	-4,399

Baseline Efficiency:

The baseline is a manual switch from the heat pump to the secondary heat source (oil/propane).

High Efficiency:

The high efficiency case uses integrated controls to switch from heat pump to secondary heat source.

Measure Life:

Measure Name	Core Initiative	PA	EUL[7]	OYF	RUL	AML
DMSHP Integrated Controls Retrofit, Oil/Propane	RES_CD	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_CD	All	1.00	1.00	1.00	1.00	1.00	-0.18	0.21
DMSHP Integrated Controls Retrofit, Propane	RES_CD	All	1.00	1.00	1.00	1.00	1.00	-0.16	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[8]	SO_P	SO_{NP}	NTG
DMSHP Integrated Controls Retrofit, Oil/Propane	RES_CD	All	0.10	0.00	0.00	0.90

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 (RES 34) Engineering

Algorithm Workbook Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Agreed upon value with EEAC consultants

1.22. HVAC - DMSHP with Integrated Controls Fully Displacing Existing Boiler, Oil/Propane

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 with Integrated Controls Fully Displacing Existing Boiler, Propane	Residential Coordinated Delivery (RES_CD)	E19A2a287
DMSHP with Integrated Controls Fully Displacing Existing Boiler, Oil	Residential Coordinated Delivery (RES_CD)	E19A2a286
DMSHP with Integrated Controls Fully Displacing Existing Boiler, Propane	Residential Retail (RES_RETAIL)	E19A2c274
DMSHP with Integrated Controls Fully Displacing Existing Boiler, Oil	Residential Retail (RES_RETAIL)	E19A2c273

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on calculations provided by evaluation consultants using the following assumptions[1]:

Average home heating load = 76.7 MMBTUs [2]
Switchover temperature = 5 Degrees
Tonnage of new heat pump = 4 Tons
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
DMSHP with Integrated Controls Fully Displacing Existing Boiler, Propane	102.3	-8.67	-7,746
DMSHP with Integrated Controls Fully Displacing Existing Boiler, Oil	102.3	-8.67	-7,746

Baseline Efficiency:

For propane the baseline is an inefficient 75% AFUE boiler.[4] For oil the baseline efficiency case is an inefficient 75% AFUE boiler.[5]

For existing air conditioning, the baseline is a Room/window A/C 8 EER, Central A/C 10 SEER/ 8.5 EER.[6]

High Efficiency:

The high efficiency case is a new 20 SEER/12 HSPF ductless mini split heat pumps.

Measure Life:

Measure Name	Core Initiative	PA	EUL[7]	OYF	RUL	AML
DMSHP with Integrated Controls Fully Displacing Existing Boiler	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 with Integrated Controls Fully Displacing Existing Boiler	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	-0.02	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[8]	SO_P	SO_{NP}	NTG
DMSHP with Integrated Controls Fully Displacing Existing Boiler	RES_CD RES_RETAIL	All	0.10	0.00	0.00	0.90

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 (RES 34) Engineering Algorithm Workbook Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : Agreed upon value with EEAC consultants.
5 : Agreed upon value with EEAC consultants.
6 : Navigant Consulting (2018). RES 1 Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Agreed upon value with EEAC consultants

1.23. HVAC - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil/Propane

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 with Integrated Controls Partially Displacing Existing Boiler, Propane	Residential Coordinated Delivery (RES_CD)	E19A2a259
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil	Residential Coordinated Delivery (RES_CD)	E19A2a260
DMSHP Integrated Controls Retrofit, Propane	Residential Coordinated Delivery (RES_CD)	E19A2a261
DMSHP Integrated Controls Retrofit Oil	Residential Coordinated Delivery (RES_CD)	E19A2a262
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	Residential Retail (RES_RETAIL)	E19A2c267
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil	Residential Retail (RES_RETAIL)	E19A2c268

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on calculations provided by evaluation consultants using the following assumptions[1]:

Average Home Heating load = 76.7 MMBTUs[2]
Oil Switchover Temperature = 30 degrees
Propane Switchover Temperature = 15 degrees
Tonnage of new Heat Pump = 2.5 Tons
Proportion of homes with air conditioning: 48% (room/window), 35% (Central), 17% (none)[3]

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	84.7	-2.37	-7,564
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil	49.7	-2.04	-4,399
DMSHP Integrated Controls Retrofit, Propane	84.7	-2.37	-7,564
DMSHP Integrated Controls Retrofit, Oil	49.7	-2.04	-4,399

Baseline Efficiency:

For propane the baseline efficiency case is a 75% AFUE boiler.[4] For oil the baseline is a 75% AFUE boiler.[5]

High Efficiency:

The high efficiency case is a new 20 SEER/12 HSPF ductless mini split heat pumps.

Measure Life:

Measure Name	Core Initiative	PA	EUL[6]	OYF	RUL	AML
DMSHP with Integrated Controls	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 with Integrated Controls Partially Displacing Existing Boiler, Propane	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	-0.16	0.21
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	-0.18	0.21
DMSHP Integrated Controls Retrofit, Propane	RES_CD	All	1.00	1.00	1.00	1.00	1.00	-0.16	0.21
DMSHP Integrated Controls Retrofit, Oil	RES_CD	All	1.00	1.00	1.00	1.00	1.00	-0.18	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:

Net-to-gross factors are per agreement with the MA EEAC Consultants.

Measure Name	Core Initiative	PA	FR[7]	SO_P	SO_{NP}	NTG
DMSHP with Integrated Controls	RES_CD RES_RETAIL	All	0.10	0.00	0.00	0.90
DMSHP with Integrated Controls Partially Displacing Existing Boiler	RES_CD RES_RETAIL	All	0.10	0.00	0.00	0.90

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 (RES 34) Engineering Algorithm Workbook Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : Agreed upon value with EEAC consultants.
5 : Agreed upon value with EEAC consultants.
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 : Agreed upon value with EEAC consultants.

1.24. 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)	E19A2c006

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	0.295

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.[3]

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	0.346	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.[4]

Impact Factors for Calculating Net Savings:

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

Measure Name	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
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), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling)). 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

1.25. 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)	E19A2a036
Duct Insulation, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a037
Duct Insulation, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a038
Duct Insulation, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a039
Duct Insulation, Elec (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a117
Duct Insulation, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a118
Duct Insulation, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a119
Duct Insulation, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a120
Duct Insulation, Elec (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a205
Duct Insulation, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a206
Duct Insulation, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a207
Duct Insulation, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a208
Duct Insulation, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a003
Duct Insulation, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a048
Duct Insulation, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a082

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	0.55	
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	0.55	
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: 0.13[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	RCD	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:

PA	Measure Name	Core Initiative	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
All	Duct Insulation (Single Family)	RCD	1.00	1.00	1.00	1.00	1.00	0.34	0.21
All	Duct Insulation (Attached Low Rise)	RCD	1.00	1.00	1.00	1.00	1.00	0.34	0.21
All	Duct Insulation (High Rise)	RCD	1.00	0.86	0.86	0.86	0.86	0.34	0.17

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 demand allocation methodology described the Demand Impact Model.[6]

Impact Factors for Calculating Net Savings:

For attached low rise and high rise 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	0.00	0.00	0.00	1.00
Duct Insulation (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Duct Insulation (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

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 : Navigant Consulting (2018). Demand Impact Model Update.

2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

1.26. 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)	E19A2a040
Duct Sealing, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a041
Duct Sealing, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a042
Duct Sealing, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a043
Duct Sealing, Elec (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a113
Duct Sealing, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a114
Duct Sealing, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a115
Duct Sealing, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a116
Duct Sealing, Elec (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a201
Duct Sealing, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a202
Duct Sealing, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a203
Duct Sealing, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a204
Duct Sealing	Residential Retail (RES_RETAIL)	E19A2c010
Duct Sealing, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a004
Duct Sealing, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a049
Duct Sealing, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a083

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	0.34	
Duct Sealing, Gas (Single Family)			3.9
Duct Sealing, Oil (Single Family)			4.0
Duct Sealing, Other (Single Family)			3.9
Duct Sealing, Electric (Retail)	212	0.30	

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 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}
Duct Sealing, Electric (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.21
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	0.34	0.21
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	0.34	0.17
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
Duct Sealing, Electric (Retail)	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.346	0.00

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 demand allocation methodology described the Demand Impact Model.[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	0.00	0.00	0.00	1.00
Duct Sealing (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Duct Sealing (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Duct Sealing (Retail)	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.

Measure Name	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, RES_RETAIL	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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
8 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

1.27. HVAC - Ductless Mini-Split Heat Pump (DMSHP)

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, SEER 18.0 HSPF 10, No Integrated Controls	Residential Coordinated Delivery (RES_CD)	E19A2a280
DMSHP, SEER 18.0 HSPF 10, No Integrated Controls	Residential Retail (RES_RETAIL)	E19A2c004
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	Residential Coordinated Delivery (RES_CD)	E19A2a278
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	Residential Retail (RES_RETAIL)	E19A2c256
Custom Heat Pumps, Displacing Electric Heat (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a248

Algorithms for Calculating Primary Energy Impact:

Except for high rise applications, DMSHP unit savings are deemed based on the following algorithms and assumptions:

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

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

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

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

Where:
Unit = Installation of DMSHP system
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)[2]	Average SEER[3]	Average HSPF[4]	Cooling Hours[5] Heating Hours[6]	ΔkWh	Annual Max Demand Factor[7]	ΔkW
DMSHP, SEER 18.0 HSPF 10, No Integrated Controls	Electric	1.78	22.2	11.5	218 (cool) 535 (heat)	499.0	0.001660 (cool) 0.000438 (heat)	0.174
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	Electric	1.78	22.2	11.5	218 (cool) 1,117 (heat)	5,039	0.001660 (cool) 0.000438 (heat)	2.163
Custom Heat Pumps, Displacing Electric Heat (High Rise)	Electric	N/A	N/A	N/A	Vendor calculated	Vendor calculated	Vendor calculated	Vendor calculated

Baseline Efficiency:

Except for high rise applications, the baseline is a code-compliant, 2.2-ton, SEER 15.0, HSPF 8.2 DMSHP system.[8] For displacement of electric heat, the equivalent HSPF for electric resistance heat is assumed to be 3.4.[9]

For high rise retrofit applications, the baseline is typically existing conditions of the participating building or housing units.

High Efficiency:

Except for high rise applications, the high efficiency case is a 1.78-ton, SEER 22.2, HSPF 11.5 DMSHP system, based on the average capacity and efficiency levels of systems rebated in the previous calendar year.

For high rise retrofit applications, the high efficiency case reflects the project-specific capacity, efficiency, and operating levels of the installed DMSHP system(s).

Measure Life:

The measure life is based on evaluation results.[10]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
DMSHP, SEER 18.0 HSPF 10, No Integrated Controls	RES_CD RES_RETAIL	All	18	n/a	n/a	18
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	RES_CD RES_RETAIL	All	18	n/a	n/a	18
Custom Heat Pumps, Displacing Electric Heat (High Rise)	RES_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, SEER 18.0 HSPF 10, No Integrated Controls	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.274	0.62
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.022	0.62
Custom Heat Pumps, Displacing Electric Heat (High Rise)	RES_CD	All	1.00	0.86	0.86	0.86	0.86	custom	custom

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.[11]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[12]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
DMSHP, SEER 18.0 HSPF 10, No Integrated Controls	RES_CD RES_RETAIL	All	40.6%	2.0%	15.2%	76.6%
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	RES_CD RES_RETAIL	All	40.6%	2.0%	15.2%	76.6%
Custom Heat Pumps, Displacing Electric Heat (High Rise)	RES_CD	All	21.0%	13.0%	17.0%	109.0%

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, SEER 18.0 HSPF 10, No Integrated Controls	RES_CD RES_RETAIL	All	$4.21	$0.00	$0.00	$0.00	N/A	N/A
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat	RES_CD RES_RETAIL	All	$4.21	$0.00	$0.00	$0.00	N/A	N/A
Custom Heat Pumps, Displacing Electric Heat (High Rise)	RES_CD	All	$5.98	$0.00	$0.00	$0.00	N/A	N/A

Endnotes:

1 : The calculation of unit savings can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations
2 : Average capacity (tons) of heat pump units rebated in the full calendar year preceding the year in which this eTRM is published.
3 : Average SEER of heat pump units rebated in the full calendar year preceding the year in which this eTRM is published.
4 : Average HSPF of heat pump units 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, December 30, 2016. Cadmus_2016_DMSHP_Impact_Evaluation
6 : 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, December 30, 2016. Navigant_2018_DMSHP_Survey

7 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

8 : Navigant Consulting (2018). Ductless Mini-Split Heat Pump Survey.
Navigant_2018_DMSHP_Survey

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 : Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Ductless Mini Split Heat Pumps (heating and cooling)). The calculation of coincidence factors combined for heating and cooling can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

12 : NMR Group (2018), Massachusetts Residential HVAC NTG and Market Effects Study.
2018_NMR_Res_HVAC_NTG_ME_Study

1.28. 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 Coordinated Delivery (RES_CD)	E19A2a006
DMSHP QIV	Residential Retail (RES_RETAIL)	E19A2c106

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[8]	ΔkW
DMSHP QIV	Electric	1.8	22.2	11.5	218 (cool) 535 (heat)	60.2	0.001660 (cool) 0.000438 (heat)	0.022

Baseline Efficiency:

The baseline efficiency case is a new MSHP system (1.8-ton, SEER 22.2, and HSPF 11.5), 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.[9]

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	0.228	0.62

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.[10]

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' 2019 Annual Report Electric Heating and Cooling Savings Workbook (2019). MA_PAs_2019-2021 Electric_HVAC_Calculations
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 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.
5 : 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.
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 : Navigant Consulting (2018). Demand Impact Model Update 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
9 : 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
10 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

1.29. 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)	E19A2c009

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results.[1]

Measure Name	ΔkWh	ΔkW
Circulator Pump	142	0.08

Baseline Efficiency:

The baseline efficiency case is the installation of a standard circulator pump.

High Efficiency:

The high efficiency case is the installation of an ECM circulator pump.

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	0.53

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	RES_RETAIL	All	0.0%	0.0%	0.0%	100.0%

Non-Energy Impacts:

There are no non-energy impacts for this measure.

Endnotes:

1 : The Cadmus Group (2012). Impact Evaluation of the 2011-2012 ECM Circulator Pump Pilot Program. Savings Values shown in MA PAs (2015). ECM Circulator Pump Savings Calculations Workbook. MA_PAs_2015_ECM_Circulator_Pumps_Savings_Doc
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

1.30. HVAC - Forced Hot Water Boiler, Gas

Measure Code	RES-HVAC-BGFHW
Market	Residential
Program Type	Retrofit
Category	Heating Ventilation and Air Conditioning

Measure Description:

Installation of a new high efficiency gas-fired boiler for space heating.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Heating System, Forced Hot Water Boiler, Gas 90% (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a035
Heating System, Forced Hot Water Boiler, Gas 95% (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a036
Heating System, Forced Hot Water Boiler, Gas 90% (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a070
Heating System, Forced Hot Water Boiler, Gas 95% (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a071
Heating System, Forced Hot Water Boiler, Gas 90%	Residential Retail (RES_RETAIL)	G19A2c001
Heating System, Forced Hot Water Boiler, Gas 95%	Residential Retail (RES_RETAIL)	G19A2c002

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated based on deemed inputs and have been adjusted to reflect the mix of replace on failure and early replacement.[1]

Savings for Residential Boilers

Measure Name	ΔMMBtu
Heating System, Forced Hot Water Boiler, Gas 90%	12.1
Heating System, Forced Hot Water Boiler, Gas 95%	14.8

Baseline Efficiency:

The baseline efficiency case is an 82% AFUE rated boiler (79.3% AFUE actual). The ER baseline is an 80% AFUE rated boiler (77.4% AFUE actual).

High Efficiency:

The high efficiency case is a boiler with an AFUE rating of 90% or greater. Based on evaluation results the actual AFUE is 87.2% for a 90% AFUE rated boiler and 89.4% for a 95% AFUE rated boiler.

Measure Life:

The measure life is 19 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System, Forced Hot Water Boiler, Gas 90%	RES_CD	All	19	n/a	n/a	19
Heating System, Forced Hot Water Boiler, Gas 95%	RES_CD	All	19	n/a	n/a	19
Heating System, Forced Hot Water Boiler, Gas 90%	RES_RETAIL	All	19	n/a	n/a	19
Heating System, Forced Hot Water Boiler, Gas 95%	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}
Heating System, Forced Hot Water Boiler, Gas 90%	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Forced Hot Water Boiler, Gas 95%	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Forced Hot Water Boiler, Gas 90%	RES_RETAIL	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Forced Hot Water Boiler, Gas 95%	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 for deemed measures.

Coincidence Factors:

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

Impact Factors for Calculating Net Savings:

Net-to-Gross factors are calculated.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heating System, Forced Hot Water Boiler, Gas 90%	RES_CD	All	0.16	0.00	0.00	0.84
Heating System, Forced Hot Water Boiler, Gas 95%	RES_CD	All	0.12	0.00	0.00	0.88
Heating System, Forced Hot Water Boiler, Gas 90%	RES_RETAIL	All	0.16	0.00	0.00	0.84
Heating System, Forced Hot Water Boiler, Gas 95%	RES_RETAIL	All	0.12	0.00	0.00	0.88

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
Heating System, Forced Hot Water Boiler, Gas 90%	RES_CD	All	$80.94					
Heating System, Forced Hot Water Boiler, Gas 95%	RES_CD	All	$80.94					
Heating System, Forced Hot Water Boiler, Gas 90%	RES_RETAIL	All	$80.94					
Heating System, Forced Hot Water Boiler, Gas 95%	RES_RETAIL	All	$80.94					

Endnotes:

1 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations

2 : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Qualified Boiler. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on:

The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations

3 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations

4 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations

1.31. HVAC - Forced Hot Water Boiler, Oil/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, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a077
Heating System, Boiler, Propane 95% (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a078
Heating System, Boiler, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a165
Heating System, Boiler, Propane 95% (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a166
Heating System, Boiler, Propane 90% (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a270
Heating System, Boiler, Propane 90% (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a271
Heating System, Boiler, Oil	Residential Retail (RES_RETAIL)	E19A2c011
Heating System, Boiler, Propane 95%	Residential Retail (RES_RETAIL)	E19A2c012
Heating System, Boiler, Propane 90%	Residential Retail (RES_RETAIL)	E19A2c101

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 = 76.67 MMBTUs[1]

Energy Savings for Primary Impact[2]

Measure Name	ΔMMBtu
Heating System, Boiler, Oil	7.3
Heating System, Boiler, Propane 90%	8.8
Heating System, Boiler, Propane 95%	13.5

Baseline Efficiency:

For oil the baseline efficiency case is a code compliant oil AFUE 84% boiler.[3] For propane the baseline is a code-compliant boiler (AFUE = 82%) adjusted by a degradation factor (0.967) to account for its metered efficiency (AFUE=79.3%).[4]

High Efficiency:

For oil the high efficiency case is a new 86% AFUE oil boiler. For propane the high efficiency case AFUE 93% adjusted by a degradation factor (0.941) to account for its metered efficiency (AFUE=87.5%).[5]

Measure Life:

The measure life is 11 years for oil boilers,16 years for 90 AFUE propane boilers and 17 years for 95 AFUE propane boilers .[6]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System, Boiler, Oil	RES_CD	All	11	n/a	n/a	11
Heating System, Boiler, Propane 90%	RES_CD	All	16	n/a	n/a	16
Heating System, Boiler, Propane 95%	RES_CD	All	17	n/a	n/a	17
Heating System, Boiler, Oil	RES_RETAIL	All	11	n/a	n/a	11
Heating System, Boiler, Propane 90%	RES_RETAIL	All	16	n/a	n/a	16
Heating System, Boiler, Propane 95%	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, Boiler, Oil	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System, Boiler, Propane 90%	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Boiler, Propane 95%	RES_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Boiler, Oil	RES_RETAIL	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Boiler, Propane 90%	RES_RETAIL	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System, Boiler, Propane 95%	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 on calculations.[7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heating System, Boiler, Oil	RES_CD	All	0.18	0.00	0.00	0.82
Heating System, Boiler, Propane 90%	RES_CD	All	0.21	0.00	0.00	0.79
Heating System, Boiler, Propane 95%	RES_CD	All	0.24	0.00	0.00	0.76
Heating System, Boiler, Oil	RES_RETAIL	All	0.18	0.00	0.00	0.82
Heating System, Boiler, Propane 90%	RES_RETAIL	All	0.21	0.00	0.00	0.79
Heating System, Boiler, Propane 95%	RES_RETAIL	All	0.24	0.00	0.00	0.76

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, Boiler, Oil	RES_CD	All	$96.40					
Heating System, Boiler, Propane 90%	RES_CD	All	$96.40					
Heating System, Boiler, Propane 95%	RES_CD	All	$96.40					
Heating System, Boiler, Oil	RES_RETAIL	All	$96.40					
Heating System, Boiler, Propane 90%	RES_RETAIL	All	$96.40					
Heating System, Boiler, Propane 95%	RES_RETAIL	All	$96.40					

Endnotes:

1 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. 2018_Navigant_HES_Impact_Evaluation
2 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations
3 : http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf
4 : The Cadmus Group, Inc. (2015). High Efficiency Heating Equipment Impact Evaluation. CADMUS_2014_HEHE_Impact Evaluation
5 : The Cadmus Group, Inc. (2015). High Efficiency Heating Equipment Impact Evaluation. CADMUS_2014_HEHE_Impact Evaluation
6 : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Qualified Boiler. Lifetime has been adjusted to reflect the mix of replace on failure and early replacement based on: The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing. Prepared for the Electric and Gas Program Administrators of Massachusetts. The calculation of the adjustment can be found in: MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations
7 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations
8 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations

1.32. HVAC - Furnace, 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
Heating System, Furnace, Gas 95% (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a032
Heating System, Furnace, Gas 97% (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a034
Heating System, Furnace, Gas 95% (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a067
Heating System, Furnace, Gas 97% (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a069
Heating System, Furnace, Gas 95%	Residential Retail (RES_RETAIL)	G19A2c004
Heating System, Furnace, Gas 97%	Residential Retail (RES_RETAIL)	G19A2c006

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated based on deemed inputs and have been adjusted to reflect the mix of replace on failure and early replacement.[1]

Measure Name	ΔMMBtu	ΔkWh	ΔkW
Heating System, Furnace, Gas 95%	9.8	104.2	0.07
Heating System, Furnace, Gas 97%	10.3	104.2	0.07

Baseline Efficiency:

For the replace on failure portion the baseline efficiency case is an 85% AFUE furnace.[2]
For the early retirement portion the baseline efficiency is a 78% AFUE furnace (Actual 78.9% AFUE).

High Efficiency:

The high efficiency case is either a new furnace with AFUE >= 95% (actual 95.4% AFUE) with an electronically commutated motor installed or AFUE >= 97% (Actual 97.2% AFUE) with an electronically commutated motor installed.

Measure Life:

The measure life is 15 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System, Furnace, Gas 95%	RES_CD	All	15	n/a	n/a	15
Heating System, Furnace, Gas 97%	RES_CD	All	15	n/a	n/a	15
Heating System, Furnace, Gas 95%	RES_RETAIL	All	15	n/a	n/a	15
Heating System, Furnace, Gas 97%	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}
Heating System, Furnace, Gas 95%	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Heating System, Furnace, Gas 97%	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Heating System, Furnace, Gas 95%	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Heating System, Furnace, Gas 97%	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45

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:

Coincident factors are based on evaluation results.[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
Heating System, Furnace, Gas 95%	RES_CD	All	14%	0%	0%	86%
Heating System, Furnace, Gas 97%	RES_CD	All	8%	0%	0%	92%
Heating System, Furnace, Gas 95%	RES_RETAIL	All	14%	0%	0%	86%
Heating System, Furnace, Gas 97%	RES_RETAIL	All	8%	0%	0%	92%

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
Heating System, Furnace, Gas 95%	RES_CD	All	$92.07					
Heating System, Furnace, Gas 97%	RES_CD	All	$92.07					
Heating System, Furnace, Gas 95%	RES_RETAIL	All	$92.07					
Heating System, Furnace, Gas 97%	RES_RETAIL	All	$92.07					

Endnotes:

1 : The calculation of the adjustment can be found in MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
3 : Lifetime has been adjusted to reflect the mix of replace on failure and early replacement. The calculation of the adjustment can be found in MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations
4 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook.
6 : The calculation of the adjustment can be found in MA PAs (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. MA_PAs_2019_2021_Gas_HVAC_WH_Calculations

1.33. HVAC - Furnace, Oil/Propane

Measure Code	RES-HVAC-FOP
Market	Residential
Program Type	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 (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a079
Heating System, Furnace, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a080
Heating System, Furnace, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a167
Heating System, Furnace, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a168
Heating System, Furnace, Oil	Residential Retail (RES_RETAIL)	E19A2c013
Heating System, Furnace, Other	Residential Retail (RES_RETAIL)	E19A2c014

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 = 68.41 MMBTUs[1]

Energy Savings for Primary Energy Impact [2]

Measure Name	ΔMMBtu	ΔkWh	ΔkW
Heating System, Furnace, Oil	5.5	47.8	0.03
Heating System, Furnace, Other	12.0	107.2	0.07

Baseline Efficiency:

The baseline efficiency case is a code compliant oil furnace, AFUE 83% [3] , or an 85% AFUE[4] propane furnace.

High Efficiency:

The high efficiency case is a new 86% AFUE oil furnace or a 95% AFUE propane furnace.

Measure Life:

The measure life is 12 years for oil furnaces and 14 years for propane furnaces.[5]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System, Furnace, Oil	RES_CD	All	12	n/a	n/a	12
Heating System, Furnace, Other	RES_CD	All	14	n/a	n/a	14
Heating System, Furnace, Oil	RES_RETAIL	All	12	n/a	n/a	12
Heating System, Furnace, Other	RES_RETAIL	All	14	n/a	n/a	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}
Heating System, Furnace, Oil	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Heating System, Furnace, Other	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Heating System, Furnace, Oil	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Heating System, Furnace, Other	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.00	0.45

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

- For Heating System Replacement (Furnace), Oil the summer and winter coincidence factors are estimated using demand allocation methodology described the Navigant Demand Impact Model[6]
- Heating System Replacement (Furnace), Other the coincident factors are based on evaluation results. See HVAC - Furnace Fan Motors (ECM).

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, Oil	RES_CD	All	16%	0%	0%	84%
Heating System, Furnace, Other	RES_CD	All	14%	0%	0%	86%
Heating System, Furnace, Oil	RES_RETAIL	All	16%	0%	0%	84%
Heating System, Furnace, Other	RES_RETAIL	All	14%	0%	0%	86%

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, Oil	RES_CD	All	$99.74					
Heating System, Furnace, Other	RES_CD	All	$99.74					
Heating System, Furnace, Oil	RES_RETAIL	All	$99.74					
Heating System, Furnace, Other	RES_RETAIL	All	$99.74					

Endnotes:

1 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations
2 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations
3 : http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/cacfurn_dfr.pdf
4 : Agreed upon value with EEAC consultants
5 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook. MA_PAs_2019_2021_Oil_Propane_Calculations
6 : Navigant Consulting (2018). Demand Impact Model Update.

2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : MA PAs (2018). 2019-2021 Oil and Propane HVAC Calculations Workbook.
MA_PAs_2019_2021_Oil_Propane_Calculations

1.34. HVAC - Heat Pump - High Rise

Measure Code	RES-HVAC-HP-C
Market	Residential
Program Type	Retrofit
Category	Heating Ventilation and Air Conditioning

Measure Description:

Installation of a custom heat pump displacing electric, oil, or propane heat.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Custom Heat Pumps, Displacing Electric Heat (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a248
Custom Heat Pumps, Displacing Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a276
Custom Heat Pumps, Displacing Propane (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a277

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 (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:

Coincidence factors come from the Demand Impact Model.[1]

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 (High Rise)	RES_CD	All	0.00	0.00	0.00	1.00
Custom Heat Pumps, Displacing Oil (High Rise)	RES_CD	All	0.00	0.00	0.00	1.00
Custom Heat Pumps, Displacing Propane (High Rise)	RES_CD	All	0.00	0.00	0.00	1.00

Non-Energy Impacts:

NEIs 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 (High Rise)	RES_CD	All	$5.98					

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

Endnotes:

1 : Navigant (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
2 : 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

1.35. 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 Coordinated Delivery (RES_CD)	E19A2a003
Heat Pump Digital Check-Up/Tune-Up	Residential Retail (RES_RETAIL)	E19A2c007

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	2.85	13.0	7.7	419 (cool) 1,200 (heat)	322.0	0.001594 (cool) 0.000438 (heat)	0.117

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_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}
Heat Pump Digital Check-up/Tune-Up	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.26	0.62

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.[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_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
Heat Pump Digital Check-up/Tune-up	RES_CD RES_RETAIL	All	$1.53					

Endnotes:

1 : The calculation of the unit savings can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations
2 : Massachusetts Common Assumptions.
3 : Average capacity (tons) of heat pump 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 (cooling hours).
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Demand Impact Model Update. Value for Central Air Conditioner/Heat Pump (Cooling) and Ductless Mini-Split Heat Pumps (Heating).
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling) and Ductless Mini Split Heat Pumps (Heating)). The calculation of coincidence factors can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations

1.36. HVAC - Heat Pump Quality Installation Verification

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 Coordinated Delivery (RES_CD)	E19A2a005
Heat Pump QIV	Residential Retail (RES_RETAIL)	E19A2c105

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	2.85	17.07	9.55	419 (cool) 1,200 (heat)	257.2	0.001594 (cool) 0.000438 (heat)	0.094

Baseline Efficiency:

The baseline efficiency case is a new central heat pump system (2.85-ton, SEER 17.07, and HSPF 9.55), 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_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.246	0.62

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.[9]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heat Pump 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
Heat Pump QIV	RES_CD 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 PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations
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 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.
5 : 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.
6 : Navigant Consulting (2018). RES 1 Baseline Load Shape Study (cooling hours).
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : Navigant Consulting (2018). Demand Impact Model Update. Value for Central Air Conditioner/Heat Pump (Cooling) and Ductless Mini-Split Heat Pumps (Heating).
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling) and Ductless Mini Split Heat Pumps (Heating)). The calculation of coincidence factors can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). MA_PAs_2019-2021 Electric_HVAC_Calculations

1.37. 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.

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	7.7	-133	-0.1

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_CD 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}
Heat Recovery Ventilator	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.34	0.21

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[3]

Non-Energy Impacts:

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

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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

1.38. 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)	E19A2a048
Pipe Wrap (Heating), Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a049
Pipe Wrap (Heating), Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a050
Pipe Wrap (Heating), Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a125
Pipe Wrap (Heating), Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a126
Pipe Wrap (Heating), Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a127
Pipe Wrap (Heating), Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a213
Pipe Wrap (Heating), Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a214
Pipe Wrap (Heating), Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a215
Pipe Wrap (Heating), Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a006
Pipe Wrap (Heating), Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a051

Measure Name	Core Initiative	BCR Measure ID
Pipe Wrap (Heating), Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a085

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:

Attached Low Rise and High Rise are 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	0.00	0.00	0.00	1.00
Pipe Wrap (Heating) (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Pipe Wrap (Heating) (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

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

1.39. 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)	E19A2a059
Programmable Thermostat, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a060
Programmable Thermostat, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a061
Programmable Thermostat, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a062
Programmable Thermostat, Electric (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a142
Programmable Thermostat, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a144
Programmable Thermostat, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a145
Programmable Thermostat, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a146
Programmable Thermostat, Electric Resistance, No AC (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a230
Programmable Thermostat, Electric Resistance, With AC (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a231
Programmable Thermostat, AC Only (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a232

Measure Name	Core Initiative	BCR Measure ID
Programmable Thermostat, Heat Pump (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a233
Programmable Thermostat, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a234
Programmable Thermostat, Electric	Residential Retail (RES_RETAIL)	E19A2c054
Programmable Thermostat, Gas	Residential Retail (RES_RETAIL)	E19A2c055
Programmable Thermostat, Oil	Residential Retail (RES_RETAIL)	E19A2c056
Programmable Thermostat, Other	Residential Retail (RES_RETAIL)	E19A2c057
Programmable Thermostat, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a011
Programmable Thermostat, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a056
Programmable Thermostat, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a090
Programmable Thermostat, Gas	Residential Retail (RES_RETAIL)	G19A2c029

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1] [2]

Measure Name	ΔkWh	ΔkW[3]	kW-per-kWh	ΔMMBtu
Programmable Thermostat, Electric (Single Family)	278	0.21	0.00076	
Programmable Thermostat, Gas (Single Family)	27	0.04	0.00159	3.5
Programmable Thermostat, Oil (Single Family)	27	0.04	0.00159	3.5
Programmable Thermostat, Other (Single Family)	27	0.04	0.00159	3.5
Programmable Thermostat, Electric (Attached Low Rise)	278	0.24	0.00085	
Programmable Thermostat, Gas (Attached Low Rise)	27	0.04	0.00159	3.5

Measure Name	ΔkWh	ΔkW[3]	kW-per-kWh	ΔMMBtu
Programmable Thermostat, Oil (Attached Low Rise)	27	0.04	0.00159	3.5
Programmable Thermostat, Other (Attached Low Rise)	27	0.04	0.00159	3.5
Programmable Thermostat, Electric Resistance, No AC (High Rise)	257	0.19	0.00073	
Programmable Thermostat, Electric Resistance, With AC (High Rise)	281	0.13	0.00046	
Programmable Thermostat, AC Only (High Rise)	25	0.04	0.00159	
Programmable Thermostat, Heat Pump (High Rise)	241	0.10	0.00042	
Programmable Thermostat, Oil (High Rise)			n/a	2.3
Programmable Thermostat, Gas (High Rise)			n/a	2.3
Programmable Thermostat, Electric	278	0.22	0.00078	
Programmable Thermostat, Gas	27	0.04	0.00159	3.5
Programmable Thermostat, Oil	27	0.04	0.00159	3.5
Programmable Thermostat, Other	27	0.04	0.00159	3.5

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 15 years.[4] For Attached Low Rise and High Rise the measure persistence was estimated to be 69%[5] so the effective measure life is 10 years (15 years * 69%).

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Programmable Thermostat (Single Family)	RES_CD	All	15	n/a	n/a	15
Programmable Thermostat (Attached Low Rise)	RES_CD	All	15	n/a	n/a	10
Programmable Thermostat (High Rise)	RES_CD	All	15	n/a	n/a	10
Programmable 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}
Programmable Thermostat, Electric (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.21
Programmable Thermostat, Gas (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Oil (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Other (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Electric (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.17
Programmable Thermostat, Gas (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Oil (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Other (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
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	0.33	0.43
Programmable Thermostat, AC Only (High Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Heat Pump (High Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.17
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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Programmable Thermostat, Electric	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.34	0.20
Programmable Thermostat, Gas	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Oil	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Programmable Thermostat, Other	RES_RETAIL	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 demand allocation methodology described the Demand Impact Model,[6] as are the kWh-to-kW ratios used for BC Modeling.

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
Programmable Thermostat (Single Family)	RES_CD	All	0.11	0.00	0.00	0.89
Programmable Thermostat (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Programmable Thermostat (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Programmable Thermostat	RES_RETAIL	All	0.58	0.00	0.00	0.42

Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.[9] 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 : 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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat
EPA_2010_Lifecycle_Cost_Estimate_for_ENERGY_STAR_Programmable_Thermostats
5 : The Cadmus Group, Inc. (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Analysis. CADMUS_2012_Multifamily_Impacts_Analysis_Report
7 : NMR Group, Inc. (2011). Estimated Net-To-Gross (NTG) Factors for the Massachusetts Program Administrators (PAs) 2010 Residential New Construction Programs, Residential High Efficiency Heating Equipment (HEHE) and Multi-Family Gas Programs, and Commercial and Industrial Gas Programs. TetraTech_2011_Estimated_NTG_2010_Gas_Programs
8 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

1.40. 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 Coordinated Delivery (RES_CD)	E19A2a007
QI w/ Duct modifications	Residential Retail (RES_RETAIL)	E19A2c107

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]

Savings for Quality Installation with Duct Modification:

Measure Name	Energy Type	ΔkWh	ΔkW
QI w/ Duct modifications	Electric	513	0.850

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_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_{NE}**	RRSP	RRWP	CFSP	CFWP
QI w/ Duct	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.346	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.[3]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
QI w/Duct modifications	RES_CD 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 : 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.
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 : Coincidence factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling)).

1.41. 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)	E19A2c086

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] Capacity savings are derived from the Navigant Demand Impact Model.[2]

Measure Name	kWh	kW
Room Air Conditioner	36	0.06

Baseline Efficiency:

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

High Efficiency:

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

Measure Life:

The measure life is 8 years, per the ENERGY STAR appliance calculator.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Room Air Conditioner	RES_RETAIL	All	8	n/a	n/a	8

Other Resource 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	0.33	0.00

In-Service Rates:

All installations are assumed to have 100% in service rate.

Realization Rates:

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

Coincidence Factors:

Summer and winter coincidence factors are calculated using the methodology described in the Navigant Demand Impact Model.

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
Room Air Conditioner	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 : Energy Star (2018). Savings Calculator for Energy Star Appliances.
Energy_Star_2018_Consumer_Appliance_Calc
2 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Energy Star (2018). Savings Calculator for Energy Star Appliances.
Energy_Star_2018_Consumer_Appliance_Calc
4 : NMR Group, Inc. (2018). Products Net-to-Gross Report.
2018_NMR_Products_NTG_Consensus_Report

1.42. 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, Condensing, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a041
Water Heater, Condensing, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a075
Water Heater, Condensing, Gas	Residential Retail (RES_RETAIL)	G19A2c025

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	Δ MMBtu
Water Heater, Condensing, Gas	7.0

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: -0.02 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_CD 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_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.21	0.40

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 based on the Demand Impact Model.[4]

Impact Factors for Calculating Net Savings:

Net-to-gross for attached low rise is based on evaluation results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Water Heater, Condensing, Gas (Single Family)	RES_CD	All	0.00	0.00	0.00	1.00
Water Heater, Condensing, Gas (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, Condensing, 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.[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
Water Heater, Condensing, Gas	RES_CD RES_RETAIL	All	$0.70					

Endnotes:

1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
2 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review
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

1.43. 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)	E19A2a051
Faucet Aerator, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a052
Faucet Aerator, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a053
Faucet Aerator, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a054
Faucet Aerator, Electric (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a128
Faucet Aerator, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a129
Faucet Aerator, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a130
Faucet Aerator, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a131
Faucet Aerator, Electric (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a216
Faucet Aerator, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a217
Faucet Aerator, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a218
Faucet Aerator, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a219

Faucet Aerator, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a007
Faucet Aerator, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a052
Faucet Aerator, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a086

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1] [2]

Measure Name	ΔkWh	ΔkW[3]	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	RES_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% for deemed measures.

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 for attached low rise and high rise are based on evaluation results.[6] [7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Faucet Aerator (Single Family)	RES_CD	All	0.00	0.00	0.00	1.00
Faucet Aerator (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Faucet Aerator (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

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						

Measure Name	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 (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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Attached Low Rise: Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review
7 : High Rise: Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

1.44. 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
Water Heater, Heat Pump, <55 gallon, Energy Star (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a282
Water Heater, Heat Pump, >55 gallon, UEF 2.70 (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a283
Water Heater, Heat Pump, <55 gallon, Energy Star (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a284
Water Heater, Heat Pump, >55 gallon, UEF 2.70 (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a285
Water Heater, Heat Pump, <55 gallon, Energy Star	Residential Retail (RES_RETAIL)	E19A2c018
Water Heater, Heat Pump, >55 gallon, UEF 2.70	Residential Retail (RES_RETAIL)	E19A2c019

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results[1]

Measure Name	ΔkWh	ΔkW
Water Heater, Heat Pump, <55 gallon, Energy Star	1516[2]	0.34
Water Heater, Heat Pump, >55 gallon, UEF 2.70	197	0.04

Baseline Efficiency:

The baseline efficiency case is a new, standard efficiency electric resistance hot water heater.

High Efficiency:

The high efficiency case is a high efficiency heat pump water heater.

Measure Life:

The measure life is 13 years.[3]

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.[4]
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)

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_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.47	1.00
Water Heater, Heat Pump, >55 gallon, UEF 2.70	RES_CD RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.41	0.75

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.[5] Winter coincidence equal to 1 since gross kW savings are equal to winter peak demand savings.

Impact Factors for Calculating Net Savings:

Impact factors for net savings:[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Water Heater, Heat Pump, <55 gallon, Energy Star (Single Family)	Residential Coordinated Delivery (RES_CD)	All	21%	1%	4%	84%

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Water Heater, Heat Pump, <55 gallon, Energy Star (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	All	21%	13%	17%	109%
Water Heater, Heat Pump, <55 gallon, Energy Star	Residential Retail (RES_RETAIL)	All	21%	1%	4%	84%
Water Heater, Heat Pump, >55 gallon, UEF 2.70 (Single Family)	Residential Coordinated Delivery (RES_CD)	All	21%	1%	4%	84%
Water Heater, Heat Pump, >55 gallon, UEF 2.70 (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	All	21%	13%	17%	109%
Water Heater, Heat Pump, >55 gallon, UEF 2.70	Residential Retail (RES_RETAIL)	All	21%	1%	4%	84%

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
Water Heater, Heat Pump, <55 gallon, Energy Star	RES_CD RES_RETAIL	All		$0.70				
Water Heater, Heat Pump, >55 gallon, UEF 2.70	RES_CD RES_RETAIL	All						

Endnotes:

1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
2 : Note that this value includes a 4.8% electric penalty to account for space heating impacts.
3 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
4 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
5 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
6 : NMR Group, Inc. (2018). Massachusetts Special and Cross-Sector Studies Area, Residential HVAC Net-to-Gross and Market Effects Study. 2018_NMR_Res_HVAC_NTG_ME_Study
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

1.45. 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 (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a081
Water Heater, Indirect, Other (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a082
Water Heater, Indirect, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a169
Water Heater, Indirect, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a170
Water Heater, Indirect, Oil	Residential Retail (RES_RETAIL)	E19A2c015
Water Heater, Indirect, Other	Residential Retail (RES_RETAIL)	E19A2c016
Water Heater, Indirect, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	G19A2a045
Water Heater, Indirect, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a078
Water Heater, Indirect, Gas	Residential Retail (RES_RETAIL)	G19A2c028

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	Δ MMBtu
Water Heater, Indirect, Oil (Single Family)	4.7
Water Heater, Indirect, Other (Single Family)	4.0
Water Heater, Indirect, Oil (Attached Low Rise)	4.7
Water Heater, Indirect, Other (Attached Low Rise)	4.0
Water Heater, Indirect, Gas (Single Family)	4.0
Water Heater, Indirect, Gas (Attached Low Rise)	4.0
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_CD 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_CD 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] [4] [5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Water Heater, Indirect, Oil (Single Family)	RES_CD	All	0.29	0.00	0.00	0.71
Water Heater, Indirect, Other (Single Family)	RES_CD	All	0.29	0.00	0.00	0.71
Water Heater, Indirect, Oil (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, Indirect, Other (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, Indirect, Gas (Single Family)	RES_CD	All	0.66	0.00	0.00	0.34
Water Heater, Indirect, Gas (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, Indirect, Oil	RES_RETAIL	All	0.29	0.00	0.00	0.71
Water Heater, Indirect, Other	RES_RETAIL	All	0.29	0.00	0.00	0.71
Water Heater, Indirect, Gas	RES_RETAIL	All	0.66	0.00	0.00	0.34

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 (Single Family)	RES_CD	All	$0.70					
Water Heater, Indirect, Other (Single Family)	RES_CD	All	$0.70					
Water Heater, Indirect, Oil (Attached Low Rise)	RES_CD	All	$0.70					
Water Heater, Indirect, Other (Attached Low Rise)	RES_CD	All	$0.70					
Water Heater, Indirect, Gas (Single Family)	RES_CD	All	$0.70					

Measure Name	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, Gas (Attached Low Rise)	RES_CD	All	$0.70					
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 : The Cadmus Group (2011). 2010 Net to Gross Findings: Home Energy Assessment.
Cadmus_2011_2010_NTG_HES
4 : 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
5 : Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review

1.46. 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, Gas (Single Family)	RES_CD	G19A2a008
Low-Flow Showerhead, Gas (Attached Low Rise)	RES_CD	G19A2a053
Low-Flow Showerhead, Gas (High Rise)	RES_CD	G19A2a087
Low-Flow Showerhead, Electric (Single Family)	RES_CD	E19A2a055
Low-Flow Showerhead, Gas (Single Family)	RES_CD	E19A2a056
Low-Flow Showerhead, Oil (Single Family)	RES_CD	E19A2a057
Low-Flow Showerhead, Other (Single Family)	RES_CD	E19A2a058
Low-Flow Showerhead, Electric (Attached Low Rise)	RES_CD	E19A2a132
Low-Flow Showerhead, Gas (Attached Low Rise)	RES_CD	E19A2a133
Low-Flow Showerhead, Oil (Attached Low Rise)	RES_CD	E19A2a134
Low-Flow Showerhead, Other (Attached Low Rise)	RES_CD	E19A2a135
Low-Flow Showerhead, Electric (High Rise)	RES_CD	E19A2a220
Low-Flow Showerhead, Gas (High Rise)	RES_CD	E19A2a221
Low-Flow Showerhead, Oil (High Rise)	RES_CD	E19A2a222
Low-Flow Showerhead, Other (High Rise)	RES_CD	E19A2a223
Low-Flow Showerhead, Gas	RES_RETAIL	G19A2c034

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1] [2] kW savings are calculated using the demand impact model.[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 7 years.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead	RES_CD RES_RETAIL	All	7	n/a	n/a	7

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	1.00	1.00	1.00	n/a	n/a	0.31	0.81
Low-Flow Showerhead, Gas (Single Family)	RES_CD	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead, Oil (Single Family)	RES_CD	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead, Other (Single Family)	RES_CD	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead, Electric (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	n/a	n/a	0.31	0.81
Low-Flow Showerhead, Gas (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead, Oil (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead, Other (Attached Low Rise)	RES_CD	All	1.00	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	0.31	0.81
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:

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.[6]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Low-Flow Showerhead (Single Family)	RES_CD	All	0.00	0.00	0.00	1.00
Low-Flow Showerhead (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Low-Flow Showerhead (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Low-Flow Showerhead	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.[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
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : MA Common Assumptions
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : Attached Low Rise: Navigant Consulting (2018). Low Rise Measure Review. 2018_Navigant_Low_Rise_Measure_Review
8 : High Rise: Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation
9 : 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

1.47. 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)	RES_CD	E19A2a224
Low-Flow Showerhead with TSV, Oil (High Rise)	RES_CD	E19A2a225
Low-Flow Showerhead with TSV, Other (High Rise)	RES_CD	E19A2a226
Low-Flow Showerhead with TSV, Electric	RES_RETAIL	E19A2c078
Low-Flow Showerhead with TSV, Gas	RES_RETAIL	E19A2c079
Low-Flow Showerhead with TSV, Oil	RES_RETAIL	E19A2c080
Low-Flow Showerhead with TSV, Other	RES_RETAIL	E19A2c081
Low-Flow Showerhead with TSV, Gas	RES_RETAIL	G19A2c032
Low-Flow Showerhead with TSV, Gas (High Rise)	RES_CD	G19A2a088

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on engineering analysis.[1]

Measure Name	ΔkWh	ΔkW	Δ MMBtu
Low-Flow Showerhead with TSV, Gas (High Rise)			1.66
Low-Flow Showerhead with TSV, Electric (High Rise)	335.0	0.08	
Low-Flow Showerhead with TSV, Oil (High Rise)			1.88
Low-Flow Showerhead with TSV, Other (High Rise)			1.66
Low-Flow Showerhead with TSV, Electric	372	0.09	

Measure Name	ΔkWh	ΔkW	Δ MMBtu
Low-Flow Showerhead with TSV, Gas			1.84
Low-Flow Showerhead with TSV, Oil			2.09
Low-Flow Showerhead with TSV, Other			1.84

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 7 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead with TSV	RES_CD RES_RETAIL	All	7	n/a	n/a	7

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.[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 with TSV	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.31	0.81
Low-Flow Showerhead with TSV	RES_RETAIL	All	0.78	1.00	1.00	1.00	1.00	0.31	0.81

In-Service Rates:

In-Service rate for Res Retail is based on evaluation results.[3]

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.[4]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Low-Flow Showerhead with TSV (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Low-Flow Showerhead with TSV	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.

Measure Name	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					
Low-Flow Showerhead with TSV	RES_RETAIL	All		$0.03				

Endnotes:

1 : National Grid (2014). Review of ShowerStart evolve
National_Grid_2014_ShowerStart_Savings_Final_2015-2-9
2 : MA Common Assumptions.
3 : National Grid (2014). Review of ShowerStart evolve
National_Grid_2014_ShowerStart_Savings_Final_2015-2-9
3 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
4 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

1.48. 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 (Single Family)	RES_CD	E19A2a083
Water Heater, On-Demand, Other (Attached Low Rise)	RES_CD	E19A2a171
Water Heater, On-Demand, Other	RES_RETAIL	E19A2c017
Water Heater, On Demand, Gas (Single Family)	RES_CD	G19A2a043
Water Heater, On Demand, Gas (Attached Low Rise)	RES_CD	G19A2a077
Water Heater, On Demand, Gas	RES_RETAIL	G19A2c027

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	Δ MMBtu
Water Heater, On Demand, Gas	-43.0	-0.02	7.3
Water Heater, On-Demand, Other	-43.0	-0.02	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 0.58 UEF standalone water heater.

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[2] and 20 years for propane equipment[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Water Heater, On Demand, Gas	RES_CD RES_RETAIL	All	20	n/a	n/a	19
Water Heater, On-Demand, Other	RES_CD 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, On Demand, Gas	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.21	0.40
Water Heater, On Demand, Other	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.21	0.40
Water Heater, On Demand, Gas	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.21	0.40
Water Heater, On Demand, Other	RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.21	0.40

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.[4]

Impact Factors for Calculating Net Savings:

Net to gross factors are based on evaluation results.[5] [6]

Measure Name	Core Initiative	PA	FR	SOP	SONP	NTG
Water Heater, On Demand, Gas (Single Family)	RES_CD	All	0.29	0.00	0.00	0.71
Water Heater, On Demand, Gas (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, On-Demand, Other (Single Family)	RES_CD	All	0.29	0.00	0.00	0.71
Water Heater, On-Demand, Other (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, On Demand, Gas	RES_RETAIL	All	0.32	0.25	0.00	0.93
Water Heater, On-Demand, Other	RES_RETAIL	All	0.32	0.25	0.00	0.93

Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.[7] [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
Water Heater, On Demand, Gas	RES_CD RES_RETAIL	All	$1.23					
Water Heater, On Demand, Other	RES_CD RES_RETAIL	All	$0.70					

Endnotes:

1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo 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_2019_2021_Gas_HVAC_WH_Calculations
2 : 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_2019_2021_Gas_HVAC_WH_Calculations
3 : DOE (2008). ENERGY STAR® Residential Water Heaters: Final Criteria Analysis.
DOE_2008_ENERGY_STAR_Residential_Water_Heaters_Final_Criteria_Analysis
4 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing. Navigant Consulting (2018). Low Rise Measure Review. CADMUS_2013_HEHE_Cool Smart_NTG_Evaluation_Report

6 : Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review
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.
Tetra_Tech_and_NMR_2011_MA_Res_and_LI_NEI_Evaluation
8 : 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

1.49. 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)	RES_CD	E19A2a044
Pipe Wrap (Water Heating), Gas (Single Family)	RES_CD	E19A2a045
Pipe Wrap (Water Heating), Oil (Single Family)	RES_CD	E19A2a046
Pipe Wrap (Water Heating), Other (Single Family)	RES_CD	E19A2a047
Pipe Wrap (Water Heating), Electric (Attached Low Rise)	RES_CD	E19A2a121
Pipe Wrap (Water Heating), Gas (Attached Low Rise)	RES_CD	E19A2a122
Pipe Wrap (Water Heating), Oil (Attached Low Rise)	RES_CD	E19A2a123
Pipe Wrap (Water Heating), Other (Attached Low Rise)	RES_CD	E19A2a124
Pipe Wrap (Water Heating), Electric (High Rise)	RES_CD	E19A2a209
Pipe Wrap (Water Heating), Gas (High Rise)	RES_CD	E19A2a210
Pipe Wrap (Water Heating), Oil (High Rise)	RES_CD	E19A2a211
Pipe Wrap (Water Heating), Other (High Rise)	RES_CD	E19A2a212
Pipe Wrap (Water Heating), Gas (Single Family)	RES_CD	G19A2a005
Pipe Wrap (Water Heating), Gas (Attached Low Rise)	RES_CD	G19A2a050
Pipe Wrap (Water Heating), Gas (High Rise)	RES_CD	G19A2a084

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] [2]

Savings for Pipe Wrap (Water Heating):

Measure Name	ΔkWh	ΔkW[3]	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	0.31	0.81
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	0.31	0.81
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	0.31	0.81
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:

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[5]

Impact Factors for Calculating Net Savings:

Attached Low Rise and High Rise net to gross factors are based on evaluation results.[6] [7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pipe Wrap (Water Heating) (Single Family)	RES_CD	All	0.00	0.00	0.00	1.00
Pipe Wrap (Water Heating) (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Pipe Wrap (Water Heating) (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Navigant Consulting (2018). RCD Low-Rise Measure Review. 2018_Navigant_Low_Rise_Measure_Review
7 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

1.50. 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:

Measure Name	Core Initiative	BCR Measure ID
Water Heater, Stand Alone Water Heater, Gas (Single Family)	RES_CD	G19A2a042
Water Heater, Stand Alone Water Heater, Gas (Attached Low Rise)	RES_CD	G19A2a076
Water Heater, Stand Alone, Gas	RES_RETAIL	G19A2c026

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]

Measure Name	Core Initiative	Δ kWh	Δ kW[2]	Δ MMBtu
Water Heater, Stand Alone Water Heater, Gas	RES_CD, RES_RETAIL	-43.0	-0.02	3.0

Baseline Efficiency:

The baseline efficiency case is a standalone tank water heater with an UEF of 0.60[3]. For the early retirement portion. the baseline efficiency is an existing 0.55 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 10 years.[5]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Water Heater, Stand Alone Water Heater, Gas	RES_CD, RES_RETAIL	All	13	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}
Water Heater, Stand Alone Water Heater, Gas	RES_CD, RES_RETAIL	All	1.00	1.00	1.00	1.00	1.00	0.21	0.40

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.[6]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SOP	SONP	NTG
Water Heater, Stand Alone Water Heater, Gas (Single Family)	RES_CD	All	0.13	0.13	0.00	1.00
Water Heater, Stand Alone Water Heater, Gas (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Water Heater, Stand Alone Water Heater, Gas	RES_RETAIL	All	0.13	0.13	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
Water Heater, Stand Alone Water Heater, Gas (Single Family)	RES_CD	All	1.30	0.00	0.00	0.00	0.00	0.00
Water Heater, Stand Alone Water Heater, Gas (Attached Low Rise)	RES_CD	All	1.30	0.00	0.00	0.00	0.00	0.00
Water Heater, Stand Alone Water Heater, Gas	RES_RETAIL	All	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 7: Residential Water Heater Analysis Memo 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_2019_2021_Gas_HVAC_WH_Calculations
2 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 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_2019_2021_Gas_HVAC_WH_Calculations
6 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : 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
8 : Navigant Consulting (2018). Low Rise Measure Review.
2018_Navigant_Low_Rise_Measure_Review

1.51. 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)	E19A2a227
Thermostatic Shut-off Valve, Oil (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a228
Thermostatic Shut-off Valve, Other (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a229
Thermostatic Shutoff Valve, Elec	Residential Retail (RES_RETAIL)	E19A2c082
Thermostatic Shutoff Valve, Gas	Residential Retail (RES_RETAIL)	E19A2c083
Thermostatic Shutoff Valve, Oil	Residential Retail (RES_RETAIL)	E19A2c084
Thermostatic Shutoff Valve, Other	Residential Retail (RES_RETAIL)	E19A2c085
Thermostatic Shut-off Valve, Gas	Residential Retail (RES_RETAIL)	G19A2c033
Thermostatic Shut-off Valve, Gas (High Rise)	Residential Coordinated Delivery (RES_CD)	G19A2a089

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

Measure Name	ΔkWh	ΔkW[2]	Δ MMBtu
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 7 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Thermostatic Shut-off Valve	RES_CD RES_RETAIL	All	7	n/a	n/a	7

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

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Thermostatic Shut-off Valve (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Thermostatic Shutoff Valve	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 : 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 : MA Common Assumptions
4 : National Grid (2014). Review of ShowerStart evolve.
National_Grid_2014_ShowerStart_Savings_Final_2015-2-9
5 : NMR Group, Inc. (2018). Products Impact Evaluation of In- Service and Short Term Retention Rates Study. 2018_NMR_Products_ISR_Study
6 : Navigant Consulting (2018). Demand Impact Model Update.

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

1.52. Lighting - LED Recessed Trim Kit

Measure Code	RES-L-RTK
Market	Residential
Program Type	Retrofit
Category	Lighting

Measure Description:

LED inserts for leaky recessed light cans.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
LED Recessed Trim Kits, Electric (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a074
LED Recessed Trim Kits, Oil (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a075
LED Recessed Trim Kits, Propane (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a076
LED Recessed Trim Kits, Electric (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a153
LED Recessed Trim Kits, Oil (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a154
LED Recessed Trim Kits, Propane (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a155
LED Recessed Trim Kits, Gas (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a267
LED Recessed Trim Kits, Gas (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a275
LED Recessed Trim Kit	Residential Coordinated Delivery (RES_CD)	G19A2a018

Algorithms for Calculating Primary Energy Impact:

Air Sealing savings are deemed based on evaluation results at 94 kWh[1]; kWh Savings for the Electric Trim Kit include both Air Sealing and Reflector savings, while oil, gas and propane savings only reflect bulb savings. Refer to the "Lighting - Residential Retrofit" entry for savings derivation for the LED reflector bulb.

Measure	Electric (kWh)	Gas (MMBTu)	Oil (MMBTu)	Propane (MMBTu)
LED Recessed Trim Kits, Electric (Single Family) LED Recessed Trim Kits, Electric	136.7			
LED Recessed Trim Kits, Gas	42.7	0.37		
LED Recessed Trim Kits, Oil	42.7		0.40	
LED Recessed Trim Kits, Propane	42.7			0.40

Baseline Efficiency:

The baseline efficiency case is the existing conditions of the leaky recessed light in the participating household.

High Efficiency:

The high efficiency case is a home that has new recessed light kit installed.

Measure Life:

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
LED Recessed Trim Kits	RES_CD	All	15	n/a	n/a	3

Other Resource Impacts:

See table above for gas, oil, and propane savings.

Impact Factors for Calculating Adjusted Gross Savings:

Measure	Core Initiative	PA	ISR	RR_{EE}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Recessed Trim Kits	RES_CD	All	100%	100%	n/a	100%	100%	55%	85%

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.[4]

Impact Factors for Calculating Net Savings:

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
LED Recessed Trim Kits	RES_CD	All	12.0%	0.0%	0.0%	88.0%

Non-Energy Impacts:

NEI 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
LED Recessed Trim Kits	RES_CD	All		$3.00				

Endnotes:

1 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.
4 : Navigant Consulting (2018). Demand Impact Model Update.
5 : 1. NMR Group, Inc., Tetra Tech (2011). Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation. 2. MA PAs (2018). Residential Heating Equipment NEI Rollup.

1.53. 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)	E19A2a163
Occupancy Sensor, Common Area (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a247
Occupancy Sensor, Common Area (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a112
Occupancy Sensor, Common Area (Residential End Use)	C&I Retrofit (CI_RETRO)	E19C2a098

Algorithms for Calculating Primary Energy Impact:

Unit savings are based on the following algorithms which use averaged inputs[1]:

ΔkWh = (WattsControlled * Hours * SVG)/ 1000

Where:
Watts controlled = Connected load wattage controlled by Occupancy Sensor
Hours = Assumed run time of fixture (before the installation of occupancy sensors (Auditor Input)
Svg = Percentage of annual lighting energy saved by occupancy sensor; default of 30%

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[2]

Other Resource 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 DNV GL C&I Loadshapes Tool.[3]

Impact Factors for Calculating Net Savings:

Net to gross factors for Residential Coordinated Delivery are from the Navigant Multi-Family evaluation.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Occupancy Sensor, Common Area (Attached Low Rise) Occupancy Sensor, Common Area (High Rise) Occupancy Sensor, Common Area (Residential End Use)	RES_CD RES_CD CI_RETRO	All	0.21	0.13	0.17	1.09
Occupancy Sensor, Common Area (Multifamily)	IE_CD	All	0.00	0.00	0.00	0.00

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	RES_CD	All						

Measure Name	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 : The Cadmus Group, Inc. (2012). Massachusetts Multifamily Impact Analysis. CADMUS_2012_Multifamily_Impacts_Analysis_Report
2 : 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
3 : DNV GL (2018). C&I Loadshapes of Savings Tool 2018_DNVGL_Prescriptive_CI_Loadshapes
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

1.54. Lighting - Residential Retrofit

Measure Code	RES-L-LEDB
Market	Residential
Program Type	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	Residential New Homes & Renovations (RES_NH&R)	E19A1a004
LED Bulb	Residential New Homes & Renovations (RES_NH&R)	G19A1a004
LED Bulb (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a071
LED Bulb (Specialty) (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a072
LED Bulb (Reflectors) (Single Family)	Residential Coordinated Delivery (RES_CD)	E19A2a073
LED Bulb (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a150
LED Bulb (Specialty) (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a151
LED Bulb (Reflectors) (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a152
LED Fixture, Indoor In Unit (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a156
LED Fixture, Outdoor In Unit (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a157
LED Bulb, Common Area, Other (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a159

Measure Name	Core Initiative	BCR Measure ID
LED Fixture, Common Area (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a160
LED Fixture, Common Area, Linear (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a161
LED Fixture, Common Area, Exterior (Attached Low Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a162
LED Bulb, In-Unit (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a238
LED Bulb, In-Unit Specialty (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a239
LED Bulb, In-Unit Reflector (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a240
LED Fixture, Indoor In Unit (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a241
LED Fixture, Outdoor In Unit (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a242
LED Bulb, Common Area (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a243
LED Fixture, Indoor Common Area (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a244
LED Fixture, Linear Indoor Common Area (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a245
LED Fixture, Outdoor Common Area (High Rise)	Residential Coordinated Delivery (RES_CD)	E19A2a246
LED Bulb, In-Unit (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a089
LED Bulb, In-Unit Specialty (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a090
LED Bulb, In-Unit Reflector (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a091
LED Fixture, Indoor In Unit (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a092
LED Fixture, Outdoor In Unit (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a093
LED Bulb, Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a094

Measure Name	Core Initiative	BCR Measure ID
LED Fixture, Indoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a095
LED Fixture, Linear Indoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a096
LED Fixture, Outdoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a097
LED Bulb	Residential Coordinated Delivery (RES_CD)	G19A2a015
LED Bulb (Specialty)	Residential Coordinated Delivery (RES_CD)	G19A2a016
LED Bulb (Reflectors)	Residential Coordinated Delivery (RES_CD)	G19A2a017
LED Bulb	Residential Retail (RES_RETAIL)	E19A2c087
LED Bulb (Specialty)	Residential Retail (RES_RETAIL)	E19A2c088
LED Bulb (Hard to Reach)	Residential Retail (RES_RETAIL)	E19A2c089
LED Bulb, Food Pantries	Residential Retail (RES_RETAIL)	E19A2c090
LED Bulb (School Fundraiser)	Residential Retail (RES_RETAIL)	E19A2c091
LED Bulb (Reflectors)	Residential Retail (RES_RETAIL)	E19A2c092
LED Bulb (Linear LED)	Residential Retail (RES_RETAIL)	E19A2c093
LED Bulb, Turn-In	Residential Retail (RES_RETAIL)	E19A2c285
LED Fixture	Residential Retail (RES_RETAIL)	E19A2c094
LED Fixture (Specialty)	Residential Retail (RES_RETAIL)	E19A2c100
LED Bulb (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a033
LED Bulb (Specialty) (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a034
LED Bulb (Reflectors) (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a035
LED Bulb (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a103
Indoor Fixture (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a036

Measure Name	Core Initiative	BCR Measure ID
LED Bulb (Specialty) (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a104
LED Bulb (Reflectors) (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a105
LED Fixture, Outdoor In Unit (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a106
LED Fixture, Indoor In Unit (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a107
LED Bulb, Common Area (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a108
LED Fixture, Indoor Common Area (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a109
LED Fixture, Linear Indoor Common Area (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a110
LED Fixture, Outdoor Common Area (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a111

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. Retail HOU are adjusted to account for cross-sector sales. 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 recommend 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
kW/kWh = Average kW reduction per kWh reduction: 0.00025 kW/kWh[6]

Measure Name	Core Initiative	ΔWatts	Annual HOU	# of Bulbs	ΔKWh	ΔkW
LED Bulb	RES_NH&R	38	949	1	36.1	0.01
LED Bulb (Single Family)	RES_CD	43	949	1	40.8	0.01
LED Bulb (Specialty) (Single Family)	RES_CD	36	949	1	34.2	0.01
LED Bulb (Reflectors) (Single Family)	RES_CD	45	949	1	42.7	0.01
LED Bulb (Attached Low Rise)	RES_CD	43	949	1	40.8	0.01
LED Bulb (Specialty) (Attached Low Rise)	RES_CD	36	949	1	34.2	0.01
LED Bulb (Reflectors) (Attached Low Rise)	RES_CD	45	949	1	42.7	0.01
LED Fixture, Indoor In Unit (Attached Low Rise)	RES_CD	43	949	1.49	60.8	0.02
LED Fixture, Outdoor In Unit (Attached Low Rise)	RES_CD	43	949	2	81.6	0.02
LED Bulb, Common Area (Attached Low Rise)	RES_CD	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Fixture, Common Area (Attached Low Rise)	RES_CD	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Fixture, Common Area, Linear (Attached Low Rise)	RES_CD	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Fixture, Common Area, Exterior (Attached Low Rise)	RES_CD	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Bulb (High Rise) LED Bulb, In-Unit (Residential End Use)	RES_CD CI_RETRO	43	803	1	34.5	0.01
LED Bulb (Specialty) (High Rise) LED Bulb, In-Unit Specialty (Residential End Use)	RES_CD CI_RETRO	36	803	1	28.9	0.01

Measure Name	Core Initiative	ΔWatts	Annual HOU	# of Bulbs	ΔKWh	ΔkW
LED Bulb (Reflectors) (High Rise) LED Bulb, In-Unit Reflector (Residential End Use)	RES_CD CI_RETRO	45	803	1	36.1	0.01
LED Fixture, Indoor In Unit (High Rise) LED Fixture, Indoor In Unit (Residential End Use)	RES_CD CI_RETRO	43	803	1.49	51.4	0.01
LED Fixture, Outdoor In Unit (High Rise) LED Fixture, Outdoor In Unit (Residential End Use)	RES_CD CI_RETRO	43	803	2	69.1	0.02
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, Indoor Common Area (High Rise) LED Fixture, Indoor Common Area (Residential End Use)	RES_CD CI_RETRO	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Fixture, Linear Indoor Common Area (High Rise) LED Fixture, Linear Indoor Common Area (Residential End Use)	RES_CD CI_RETRO	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Fixture, Outdoor Common Area (High Rise) LED Fixture, Outdoor Common Area (Residential End Use)	RES_CD CI_RETRO	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated
LED Bulb	RES_RETAIL	38	1095	1	41.6	0.01
LED Bulb (Specialty)	RES_RETAIL	34	1095	1	37.2	0.01
LED (Reflectors)	RES_RETAIL	43	1095	1	47.1	0.01

Measure Name	Core Initiative	ΔWatts	Annual HOU	# of Bulbs	ΔKWh	ΔkW
LED Bulb (Linear LED)	RES_RETAIL	19.2	767	1	14.7	0.01
LED Bulb (Hard to Reach)	RES_RETAIL	38	1095	1	41.6	0.01
LED Bulb (School Fundraiser)	RES_RETAIL	38	986	1	37.5	0.01
LED Bulb, Food Pantries	RES_RETAIL	38	986	1	37.5	0.01
LED Bulb, Turn-In	RES_RETAIL	46	949	1	43.7	0.01
LED Fixture	RES_RETAIL	38	1095	1.49	62.0	0.02
LED Fixture (Specialty)	RES_RETAIL	34	1095	1.49	55.5	0.01
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
Indoor Fixture (Single Family)	IE_CD	N/A	N/A	N/A	140	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 Fixture, Indoor In Unit (Multifamily) LED Fixture, Outdoor In Unit (Multifamily) LED Bulb, Common Area (Multifamily) LED Fixture, Indoor Common Area (Multifamily) LED Fixture, Linear Indoor Common Area (Multifamily) LED Fixture, Outdoor Common Area (Multifamily)	IE_CD	Vendor Input	Varies by Space Type	N/A	Vendor Calculated	Calculated

Common Area Lighting HOU (Non-Income-Eligible)

Space Type	Annual HOU
Interior, Circulation	8,307
Interior, Other	4,115
Exterior	4,689
Parking Garage	8,760

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 Residential Retail and Residential New Homes & Renovations is a combination of an incandescent bulb, halogen bulb, and a compact fluorescent bulb. The baseline efficiency case for Residential Coordinated Delivery and Income Eligible Coordinated Delivery is a combination of an incandescent bulb and halogen bulb.

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 and take into account dual baselines.[7]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
LED Bulb	RES_NH&R RES_RETAIL	All	15	n/a	n/a	3
LED Bulb (Reflector)	RES_RETAIL	All	15	n/a	n/a	2
LED Bulb (Specialty)	RES_RETAIL	All	15	n/a	n/a	4
LED Bulb (Hard to Reach)	RES_RETAIL	All	15	n/a	n/a	3
LED Bulb (Food Pantries)	RES_RETAIL	All	15	n/a	n/a	3
LED Bulb (School Fundraiser)	RES_RETAIL	All	15	n/a	n/a	3
LED Bulb (Linear LED)	RES_RETAIL	All	15	n/a	n/a	10
LED Fixture	RES_RETAIL	All	15	n/a	n/a	3
LED Fixture (Specialty)	RES_RETAIL	All	15	n/a	n/a	4
LED Fixture	RES_RETAIL	All	21	n/a	n/a	3
LED Fixture (Specialty)	RES_RETAIL	All	10	n/a	n/a	4
LED Bulb (Single Family) LED Bulb (Attached Low Rise) LED Bulb, In-Unit (High Rise) LED Bulb, In-Unit (Residential End Use) LED Bulb (Single Family) LED Bulb (Multi Family)	RES_CD RES_CD RES_CD CI_RETRO IE_CD IE_CD	All	15	n/a	n/a	3
LED Bulb, Reflector (Single Family) LED Bulb, Reflector (Attached Low Rise) LED Bulb, In-Unit Reflector (High Rise) LED Bulb, In-Unit Reflector (Residential End Use) LED Bulb, Reflector (Single Family) LED Bulb, Reflector (Multi Family)	RES_CD RES_CD RES_CD CI_RETRO IE_CD IE_CD	All	15	n/a	n/a	3
LED Bulb, Specialty (Single Family) LED Bulb, Specialty (Attached Low Rise) LED Bulb, In-Unit Specialty (High Rise)	RES_CD RES_CD RES_CD CI_RETRO IE_CD IE_CD	All	15	n/a	n/a	3

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
LED Bulb, In-Unit Specialty (Residential End Use) LED Bulb, Specialty (Single Family) LED Bulb, Specialty (Multi Family)						
Indoor Fixture (Single Family)	IE_CD	All	15	n/a	n/a	5
LED Fixture, Indoor In Unit (Attached Low Rise) LED Fixture, Indoor In Unit (High Rise) LED Fixture, Indoor In Unit (Residential End Use) LED Fixture, Outdoor In Unit (Attached Low Rise) LED Fixture, Outdoor In Unit (High Rise) LED Fixture, Outdoor In Unit (Residential End Use) LED Fixture, Indoor In Unit (Multifamily) LED Fixture, Outdoor In Unit (Multifamily)	RES_CD RES_CD CI_RETRO RES_CD RES_CD CI_RETRO IE_CD IE_CD	All	15	n/a	n/a	5
LED Bulb, Common Area (Attached Low Rise) LED Bulb, Common Area (High Rise) LED Bulb, Common Area (Residential End Use) LED Bulb, Common Area (Multifamily)	RES_CD RES_CD CI_RETRO IE_CD	All	3	n/a	n/a	3
LED Fixture, Indoor Common Area (Attached Low Rise); LED Fixture, Indoor Common Area (High Rise) LED Bulb, Indoor Common Area (Residential End Use) LED Fixture, Indoor Common Area (Multifamily)	RES_CD RES_CD CI_RETRO IE_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 RES_CD CI_RETRO IE_CD	All	8	n/a	n/a	8

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
LED Bulb, Linear Indoor Common Area (Residential End Use) LED Fixture, Linear Indoor Common Area (Multifamily)						
LED Fixture, Common Area, Exterior (Attached Low Rise) LED Fixture, Outdoor Common Area (High Rise) LED Bulb, Outdoor Common Area (Residential End Use) LED Fixture, Outdoor Common Area (Multifamily)	RES_CD RES_CD CI_RETRO IE_CD	All	11	n/a	n/a	11

Other Resource Impacts:

There is a heat loss of 2,295 Btu/kWh applied to bulbs sold upstream to account for interactive effects.[8]

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	RES_NH&R	All	1.00	1.00	1.00	1.00	1.00	0.55	0.85
LED Bulb (Single Family) LED Bulb (Specialty) (Single Family) LED Bulb (Reflectors) (Single Family) LED Bulb (Attached Low Rise) LED Bulb (Specialty) (Attached Low Rise) LED Bulb (Reflectors) (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.55	0.85
LED Fixture, Indoor In Unit (Attached Low Rise) LED Fixture, Outdoor In Unit (Attached Low Rise)	RES_CD	All	0.88	1.00	1.00	1.00	1.00	0.55	0.85
LED Bulb, Common Area, (Attached Low Rise) LED Fixture, Common Area (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.80	0.61

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Fixture, Common Area, Linear (Attached Low Rise)									
LED Fixture, Common Area, Exterior (Attached Low Rise)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.0	1.0
LED Bulb, In-Unit (High Rise) LED Bulb, In-Unit (Residential End Use) LED Bulb, In-Unit Specialty (High Rise) LED Bulb, In-Unit Specialty (Residential End Use) LED Bulb, In Unit Reflector (High Rise) LED Bulb, In Unit Reflector (Residential End Use)	RES_CD CI_RETRO RES_CD CI_RETRO RES_CD CI_RETRO	All	0.88	1.00	1.00	1.00	1.00	0.55	0.85
LED Fixture, Indoor In Unit (High Rise) LED Fixture, Indoor In Unit (Residential End Use) LED Fixture, Outdoor In Unit (High Rise) LED Fixture, Outdoor In Unit (Residential End Use)	RES_CD CI_RETRO RES_CD CI_RETRO	All	0.88	1.00	1.00	1.00	1.00	0.55	0.85
LED Bulb, Common Area (High Rise) LED Bulb, Common Area (Residential End Use) LED Fixture, Indoor Common Area (High Rise) LED Fixture, Indoor Common Area (Residential End Use) LED Fixture, Linear Indoor Common Area (High Rise) LED Fixture, Linear Indoor Common Area (Residential End Use)	RES_CD CI_RETRO RES_CD CI_RETRO RES_CD CI_RETRO	All	1.00	1.00	1.00	1.00	1.00	0.80	0.61
LED Fixture, Outdoor Common Area (High Rise) LED Fixture, Outdoor Common Area (Residential End Use)	RES_CD CI_RETRO	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
LED Bulb	RES_RETAIL	All	0.91	1.01	1.00	1.20	0.93	0.55	0.85

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Bulb (Hard to Reach)	RES_RETAIL	All	0.91	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb (Specialty)	RES_RETAIL	All	0.92	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb (Reflector)	RES_RETAIL	All	0.92	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb (Food Pantries)	RES_RETAIL	All	0.50	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb (School Fundraiser)	RES_RETAIL	All	0.50	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb (Linear LED)	RES_RETAIL	All	0.97	1.00	1.00	1.00	1.00	0.55	0.85
LED Fixture	RES_RETAIL	All	1.00	1.01	1.00	1.20	0.93	0.55	0.85
LED Fixture (Specialty)	RES_RETAIL	All	1.00	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb (Single Family) LED Bulb (Specialty) (Single Family) LED Bulb (Reflectors) (Single Family) Indoor Fixture (Single Family) LED Bulb (Multifamily) LED Bulb (Specialty) (Multifamily) LED Bulb (Reflectors) (Multifamily) LED Fixture, Indoor In Unit (Multifamily) LED Fixture, Outdoor In Unit (Multifamily)	IE_CD	All	1.00	1.01	1.00	1.20	0.93	0.55	0.85
LED Bulb, Common Area (Multifamily) LED Fixture, Indoor Common Area (Multifamily) LED Fixture, Linear Indoor Common Area (Multifamily)	IE_CD	All	1.00	Varies by PA	Varies by PA	Varies by PA	Varies by PA	0.80	0.61
LED Fixture, Outdoor Common Area (Multifamily)	IE_CD	All	1.00	PA Specific	PA Specific	PA Specific	PA Specific	0.00	1.00

In-Service Rate:

Residential Retail ISRs are based on evaluation.[9]
Residential Coordinated Delivery high rise ISRs are based on evaluation.[10] All other Direct Install ISRs are assumed to be 100%.

Realization Rates:

Realization Rates for Residential Retail account for Interactive Effects.[11]

Realization rates for Multifamily Common Area Lighting in Income Eligible Coordinated Delivery are PA specific and based on evaluation.[12]

Realization rates for in-unit lighting are 100% as savings are deemed; realization rates for non-income-eligible Common Area lighting are also 100% as vendors are using deemed HOU by space type.[13]

Impact Factors for Calculating Net Savings:

Net to gross factors for Residential Retail and Residential New Homes and Renovations are from the NMR LED NTG Consensus study.[14] Net to gross factors for Residential Coordinated Delivery (except high rise and common area LED Bulbs) are from the HES Lighting NTG study.[15] Net to gross factors for Residential Coordinated Delivery high rise and common area LED Bulb are from the Navigant Multi-Family evaluation.[16]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
LED Bulb	RES_NH&R	All	0.65	0.0	0.0	0.35
LED Bulb (Single Family) LED Bulb (Attached Low Rise) LED Bulb (Specialty) (Single Family) LED Bulb (Specialty) (Attached Low Rise) LED Bulb (Reflectors) LED Bulb (Reflectors) (Attached Low Rise)	RES_CD	All	0.12	0.0	0.0	0.88
LED Fixture, Indoor In Unit (Attached Low Rise) LED Fixture, Outdoor In Unit (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
LED Bulb, Common Area (Attached Low Rise) LED Fixture, Common Area (Attached Low Rise) LED Fixture, Common Area, Linear (Attached Low Rise) LED Fixture, Common Area, Exterior (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
LED Bulb, In-Unit (High Rise) LED Bulb, In-Unit (Residential End Use) LED Bulb, In-Unit Specialty (High Rise) LED Bulb, In-Unit Specialty (Residential End Use) LED Bulb, In Unit Reflector (High Rise) LED Bulb, In Unit Reflector (Residential End Use)	RES_CD CI_RETRO RES_CD CI_RETRO RES_CD CI_RETRO	All	0.21	0.13	0.17	1.09

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
LED Fixture, Indoor In Unit (High Rise) LED Fixture, Indoor In Unit (Residential End Use) LED Fixture, Outdoor In Unit (High Rise) LED Fixture, Outdoor In Unit (Residential End Use)	RES_CD CI_RETRO RES_CD CI_RETRO	All	0.21	0.13	0.17	1.09
LED Bulb, Common Area (High Rise) LED Bulb, Common Area (Residential End Use) LED Fixture, Indoor Common Area (High Rise) LED Fixture, Indoor Common Area (Residential End Use) LED Fixture, Linear Indoor Common Area (High Rise) LED Fixture, Linear Indoor Common Area (Residential End Use) LED Fixture, Outdoor Common Area (High Rise) LED Fixture, Outdoor Common Area (Residential End Use)	RES_CD CI_RETRO RES_CD CI_RETRO RES_CD CI_RETRO RES_CD CI_RETRO	All	0.21	0.13	0.17	1.09
LED Bulb	RES_RETAIL	All	0.65	0.0	0.0	0.35
LED Bulb (Hard to Reach)	RES_RETAIL	All	0.65	0.0	0.0	0.35
LED Bulb (Specialty)	RES_RETAIL	All	0.55	0.0	0.0	0.45
LED Bulb (Reflector)	RES_RETAIL	All	0.55	0.0	0.0	0.45
LED Bulb (Food Pantries)	RES_RETAIL	All	0.0	0.0	0.0	0.0
LED Bulb (School Fundraiser)	RES_RETAIL	All	0.65	0.0	0.0	0.35
LED Bulb Turn-In	RES_RETAIL	All	0.38	0.0	0.0	0.62
LED Bulb (Linear LED)	RES_RETAIL	All	0.55	0.0	0.0	0.45
LED Fixture	RES_RETAIL	All	0.55	0.00	0.00	0.45
LED Fixture (Specialty)	RES_RETAIL	All	0.55	0.00	0.00	0.45
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) Indoor Fixture (Single Family) LED Fixture, Indoor In Unit (Multifamily) LED Fixture, Outdoor In Unit (Multifamily) LED Bulb, Common Area (Multifamily) LED Fixture, Indoor Common Area (Multifamily) LED Fixture, Linear Indoor Common Area (Multifamily) LED Fixture, Outdoor Common Area (Multifamily)	IE_CD	All	0.0	0.0	0.0	0.0

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
LED Bulb	RES_NH	All		$3.00				
LED Bulb (Single Family) LED Bulb (Attached Low Rise) LED Bulb (Specialty) (Single Family) LED Bulb (Specialty) (Attached Low Rise) LED Bulb (Reflectors) (Single Family) LED Bulb (Reflectors) (Attached Low Rise)	RES_CD	All		$3.00				
LED Fixture, Indoor In Unit (Attached Low Rise) LED Fixture, Outdoor In Unit (Attached Low Rise)	RES_CD	All		$3.50				
LED Bulb, Common Area (Attached Low Rise) LED Fixture, Common Area (Attached Low Rise) LED Fixture, Common Area, Linear (Attached Low Rise) LED Fixture, Common Area, Exterior (Attached Low Rise)	RES_CD	All	Varies by PA		$0.027			
LED Bulb (High Rise) LED Bulb (Specialty) (High Rise) LED Bulb (Reflectors) (High Rise) LED Bulb (Residential End Use) LED Bulb (Specialty) (Residential End Use) LED Bulb (Reflectors) (Residential End Use)	RES_CD RES_CD RES_CD CI_RETRO CI_RETRO CI_RETRO	All		$3.00				
LED Fixture, Indoor In Unit (High Rise)	RES_CD RES_CD	All		$3.50				

Measure Name	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, Outdoor In Unit (High Rise) LED Fixture, Indoor In Unit (Residential End Use) LED Fixture, Outdoor In Unit (Residential End Use)	CI_RETRO CI_RETRO							
LED Bulb, Common Area (High Rise) LED Fixture, Indoor Common Area (High Rise) LED Fixture, Linear Indoor Common Area (High Rise) LED Fixture, Outdoor Common Area (High Rise) LED Bulb, Common Area (Residential End Use) LED Fixture, Indoor Common Area (Residential End Use) LED Fixture, Linear Indoor Common Area (Residential End Use) LED Fixture, Outdoor Common Area (Residential End Use)	RES_CD RES_CD RES_CD RES_CD CI_RETRO CI_RETRO CI_RETRO CI_RETRO	All	Varies by PA		$0.027			
LED Bulb LED Bulb (Hard to Reach) LED Bulb (Specialty) LED Bulb (Reflector) LED Bulb (Food Pantries) LED Bulb (School Fundraiser) LED Bulb (Linear LED) LED Bulb Turn-In	RES_RETAIL	All		$3.00				
LED Fixture LED Fixture (Specialty)	RES_RETAIL	All		$3.50				
LED Bulb (Single Family) LED Bulb (MultiFamily) LED Bulb (Specialty) (Single Family) LED Bulb (Specialty) (MultiFamily)	IE_CD	All			Varies by PA	$0.005		

Measure Name	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 (Reflectors) (Single Family) LED Bulb (Reflectors) (MultiFamily)								
Indoor Fixture (Single Family)	IE_CD	All			Varies by PA	$0.005		
LED Fixture, Indoor In Unit (Multifamily) LED Fixture, Outdoor In Unit (Multifamily)	IE_CD	All			Varies by PA	$0.005		
LED Bulb, Common Area (Multifamily) LED Fixture, Indoor Common Area (Multifamily) LED Fixture, Linear Indoor Common Area (Multifamily) LED Fixture, Outdoor Common Area (Multifamily)	IE_CD	All	Varies by PA		Varies by PA	$0.005		

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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : NMR Group, Inc. (2018). Home Energy Assessment LED Net-to-Gross Consensus. NMR_2018_HEA_LED_NTGpdf
8 : The Cadmus Group (2016). MA Lighting Interactive Effects Study. Cadmus_2016_MA_Lighting_Interactive_Effects_Final
9 : NMR Group, Inc. (2018). 2019-2021 Planning Assumptions: Lighting Hours-of-Use and In-Service Rate. 2018_NMR_LTGHOU_ISR
10 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation
11 : The Cadmus Group (2016). MA Lighting Interactive Effects Study. Cadmus_2016_MA_Lighting_Interactive_Effects_Final
12 : The Cadmus Group (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.

CADMUS_2015_Low_Income_Multifamily_Impact_Evaluation
13 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
14 : NMR Group, Inc. (2018). LED Net-to-Gross Consensus Panel Report.
2018_NMR_LED_NTG_Consensus
15 : NMR Group, Inc. (2018). Home Energy Assessment LED Net-to-Gross Consensus.
NMR_2018_HEA_LED_NTGpdf
16 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

1.55. Motor - Pool Pump

Measure Code	RES-MAD-PP
Market	Residential
Program Type	Retrofit
Category	Motors and Drives

Measure Description:

The installation of a 2-speed or variable-speed drive pool pump. Operating a pool pump for a longer period of time at a lower wattage can move the same amount of water, using significantly less energy.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Pool Pump (Two Speed)	Residential Coordinated Delivery (RES_CD)	E19A2a001
Pool Pump (Variable Speed)	Residential Coordinated Delivery (RES_CD)	E19A2a002
Pool Pump (Two Speed)	Residential Retail (RES_RETAIL)	E19A2c070
Pool Pump (Variable Speed)	Residential Retail (RES_RETAIL)	E19A2c071

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on averaged results from the ENERGY STAR pool pump calculator.[1] The calculator was run for 6 scenarios: a two-speed replacement pump and a variable-speed replacement pump, for three baseline sizes ranging from 1HP to 2HP.

For each pump, the run time was set to achieve 1.5 turnovers per day, with 2 hours at high speed for cleaning. For 1 horsepower pumps, pool size was assumed to be 20,000 gallons. For 1.5 horsepower pumps, pool size was assumed to be 22,500 gallons. For 2 horsepower pumps, pool size was assumed to be 23,000 gallons

Demand savings are derived from the Navigant Demand Impact Model.[2]

Measure Name	ΔkWh	ΔkW
Pool Pump (Two Speed)	842	0.87
Pool Pump (Variable Speed)	1,062	1.12

Baseline Efficiency:

The baseline efficiency case is a single speed 1.5 horsepower pump that pumps 64 gallons per minute and runs 8.5 hours per day for 91 days a year. It has an EF = 2.1 and cycles 32,640 gallons per day.

High Efficiency:

For a two-speed pump the high efficiency case is a 2.0 HP pump rated at 66 gpm high speed (oversized motor compared to the base case). It has a 2.0 EF at high speed, a 5.2 EF at low speed (50% flow) and runs 2 hr/day at high speed for filter & cleaning and 12.5 hr/day for filtering alone to deliver the equivalent total gallons of cycling per day.

For a variable-speed pump the high efficiency case is a pump rated at 50 gpm high speed. It has a 4.0 EF at high speed, an 8.8EF at low speed and runs 2 hr/day at high speed for filter & cleaning and 18 hr/day for filtering alone.

Measure Life:

The measure life is 10 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Pool pump	RES_CD 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}
Pool Pump (Two Speed)	RES_CD RES_RETAIL	All	1.00	1.00	n/a	1.00	1.00	0.55	0.00
Pool Pump (Variable Speed)	RES_CD RES_RETAIL	All	1.00	1.00	n/a	1.00	1.00	0.55	0.00

In-Service Rates:

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

Realization Rates:

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

Coincidence Factor:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.

Impact Factors for Calculating Net Savings:

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

2019

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pool Pump (Two Speed)	RES_CD RES_RETAIL	All	0.05	0.00	0.00	0.95
Pool Pump (Variable Speed)	RES_CD RES_RETAIL	All	0.05	0.00	0.00	0.95

2020

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pool Pump (Two Speed)	RES_CD RES_RETAIL	All	0.07	0.00	0.00	0.93
Pool Pump (Variable Speed)	RES_CD RES_RETAIL	All	0.07	0.00	0.00	0.93

2021

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pool Pump (Two Speed)	RES_CD RES_RETAIL	All	0.09	0.00	0.00	0.91
Pool Pump (Variable Speed)	RES_CD RES_RETAIL	All	0.09	0.00	0.00	0.91

Non-Energy Impacts:

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

Endnotes:

1 : http://www.energystar.gov/sites/default/files/asset/document/Pool%20Pump%20Calculator.xlsx
2 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Davis Energy Group (2008). Proposal Information Template for Residential Pool Pump Measure Revisions. Prepared for Pacific Gas and Electric Company.
Davis_Energy_Group_2008_Proposal_Info_Template_for_Residential_Pool_Pump_Measure_Revisions
4 : NMR Group, Inc. (2018). Products Net-to-Gross Report.
2018_NMR_Products_NTG_Consensus_Report

1.56. 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
Motors & VFD - Custom	Residential Coordinated Delivery (RES_CD)	E19A2a250

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 (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 Circulat-ing 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	Multi-Family	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218

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
Savings Factors (kW/HP_{SP})										
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 lifetime is 13 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
VFDs (High Rise)	RES_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}
VFDs (High Rise)	RES_CD	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 (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09

Non-Energy Impacts:

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

Endnotes:

1 : Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at 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 : 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 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

1.57. 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)	E19A2a008
Smart Strip, Tier 2	Residential Coordinated Delivery (RES_CD)	E19A2a009
Smart Strip, Tier 1	Residential Retail (RES_RETAIL)	E19A2c073
Smart Strip, Tier 2	Residential Retail (RES_RETAIL)	E19A2c074
Smart Strip, Tier 1	Residential Coordinated Delivery (RES_CD)	G19A2a116
Smart Strip, Tier 2	Residential Coordinated Delivery (RES_CD)	G19A2a117

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Savings for Smart Strips

Measure Name	Core Initiative	kWh	kW
Smart Strip, Tier 1	All	105	0.010
Smart Strip, Tier 2	All	207	0.024

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.[2]

Other Resource 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, Tier 1	RES_CD	All	0.81	0.92	0.92	0.92	1.00	1.00
Smart Strip, Tier 2	RES_CD	All	0.74	0.92	0.92	0.92	1.00	1.00
Smart Strip, Tier 1	RES_RETAIL	All	0.81	0.92	0.92	0.92	1.00	1.00
Smart Strip, Tier 2	RES_RETAIL	All	0.74	0.92	0.92	0.92	1.00	1.00

In-Service Rates:

In-service rates are based on consumer surveys, as found in the referenced study.[3]

Realization Rates:

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[4]

Coincidence Factors:

Summer and winter coincidence factors are from the referenced study.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	NTG
Smart Strip, Tier 1	RES_CD RES_RETAIL	All	1.00
Smart Strip, Tier 2	RES_CD RES_RETAIL	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 : Massachusetts Common Assumption
3 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
4 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. 2019_NMR_APSMeteringReport_Revised
5 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. 2018_NMR_APS_Metering_Report

1.58. 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)	E19A2a249

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	0.184	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	1.00	0.86	0.86	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 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	0.21	0.13	0.17	1.09

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

1.59. 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 (Single Family)	Residential Coordinated Delivery (RCD)	E19A2a086
Solar Hot Water (Attached Low Rise)	Residential Coordinated Delivery (RCD)	E19A2a174

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 (Single Family)	RES_CD	All	20	n/a	n/a	20
Solar Hot Water (Attached Low Rise)	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}
Solar Hot Water (Single Family)	RES_CD	All	1.00	1.00	1.00	1.00	1.00	0.31	0.81
Solar Hot Water (Attached Low Rise)	RES_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.[3]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[4] [5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Solar Hot Water (Single Family)	RES_CD	All	0.29	0.00	0.00	0.71
Solar Hot Water (Attached Low Rise)	RES_CD	ALL	0.21	0.13	0.17	1.09

Non-Energy Impacts:

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

Endnotes:

3 : Navigant Consulting (2018). Demand Impact Model Update.

1.60. Whole Home - New Construction

Measure Code	RES-BE-RNC
Market	Residential
Program Type	New Construction
Category	Heating Ventilation and Air Conditioning, Water Heating

Measure Description:

To capture lost opportunities, encourage the construction of energy-efficient homes, and drive the market to one in which new homes are moving towards net-zero energy.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Heating (New Construction)	Residential New Homes & Renovations (RES_NH&R)	E19A1a001
Cooling (New Construction)	Residential New Homes & Renovations (RES_NH&R)	E19A1a002
Water Heating (New Construction)	Residential New Homes & Renovations (RES_NH&R)	E19A1a003
Heating (Renovations)	Residential New Homes & Renovations (RES_NH&R)	E19A1a005
Cooling (Renovations)	Residential New Homes & Renovations (RES_NH&R)	E19A1a006
Water Heating (Renovations)	Residential New Homes & Renovations (RES_NH&R)	E19A1a007
Heating (High Rise)	Residential New Homes & Renovations (RES_NH&R)	E19A1a008
Cooling (High Rise)	Residential New Homes & Renovations (RES_NH&R)	E19A1a009
Water Heating (High Rise)	Residential New Homes & Renovations (RES_NH&R)	E19A1a010
Lighting (High Rise)	Residential New Homes & Renovations (RES_NH&R)	E19A1a011
Heating (New Construction)	Residential New Homes & Renovations (RES_NH&R)	G19A1a001
Cooling (New Construction)	Residential New Homes & Renovations (RES_NH&R)	G19A1a002
Water Heating (New Construction)	Residential New Homes & Renovations (RES_NH&R)	G19A1a003
Heating (Renovations)	Residential New Homes & Renovations (RES_NH&R)	G19A1a005
Cooling (Renovations)	Residential New Homes & Renovations (RES_NH&R)	G19A1a006
Water Heating (Renovations)	Residential New Homes & Renovations (RES_NH&R)	G19A1a007

Measure Name	Core Initiative	BCR Measure ID
Heating (High Rise)	Residential New Homes & Renovations (RES_NH&R)	G19A1a008
Cooling (High Rise)	Residential New Homes & Renovations (RES_NH&R)	G19A1a009
Water Heating (High Rise)	Residential New Homes & Renovations (RES_NH&R)	G19A1a010
Lighting (High Rise)	Residential New Homes & Renovations (RES_NH&R)	G19A1a011

Algorithms for Calculating Primary Energy Impact:

Savings are derived from three components within this initiative: Low-Rise Performance Path, Low-Rise Prescriptive Path, and Multifamily High-Rise Path.

The Program Administrators currently use vendor calculated energy savings for Low-Rise Performance Path projects. These savings are calculated using a RESNET accredited Rating Software Tool (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 program via the Low-Rise Prescriptive Path, deemed savings are applied to each unit completing the requirements of the Program. The deemed savings were derived by the program vendor using energy simulation tools to create a sample set of homes that represented every type of home that would typically participate in the initiative, including various building types, sizes, fuel types, HVAC system types and climate locations.

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	Core Initiative	PA	kW-per-kWh
Heating	RNH&R	All Electric PAs	0.00073
Heating	RNH&R	All Gas PAs	0.00064
Cooling	RNH&R	All	0.00159
Water Heating	RNH&R	All	0.00024
Lighting (High Rise)	RNH&R	All	0.00025

Baseline Efficiency:

The User-Defined Reference Home (UDRH) was revised for 2019 as a result of the baseline study completed in 2019.[1] The Multifamily High-Rise baseline is evaluated separately.[2]

Renovation project savings are measured against an existing conditions baseline. This baseline is subject to change for 2020 projects.[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	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	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating	RNH&R	All Electric PAs	1.00	1.00	1.00	1.00	1.00	0.00	0.43
Heating	RNH&R	All Gas PAs	1.00	1.00	1.00	1.00	1.00	0.00	0.45
Cooling	RNH&R	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Water Heating	RNH&R	All	1.00	1.00	1.00	1.00	1.00	0.31	0.81
Lighting (High Rise)	RNH&R	All	1.00	1.00	1.00	1.00	1.00	0.55	0.85

In-Service Rates:

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

Realization Rates:

Realization rates are 100% because energy and demand savings are custom-calculated based on project specific detail.

Coincidence Factors:

Coincidence factors are 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
Heating, Cooling, and Water Heating	RNH&R	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. 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	$117.00					
Cooling (New Construction)	RNH&R	All						
Water Heating (New Construction)	RNH&R	All						
LED Bulb	RNH&R	All		$3.00				
Heating (Renovations)	RNH&R	All	$117.00					
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 : Navigant Consulting (2018). Demand Impact Model Update.

2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : NMR Group, Inc. (2018). Residential New Construction and CCSI Attribution Assessment.
2018_NMR_RNC_CCSI_Attribution

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)	E19B1a121

Algorithms for Calculating Primary Energy Impact:

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

ΔkWh = Capacity * (0.473/24) * ((1/EffRETIRE) - (1/EffEE)) * Hours

Where:
Capacity = Average capacity of dehumidifier in Pints/24 Hours: 35 Pints/Day[1]
EffRETIRE = Average efficiency of model being recycled, in Liters/kWh
EffEE = Efficiency of ENERGY STAR® model, in Liters/kWh
Hours = Dehumidifier annual operating hours
0.473 = Conversion factor: 0.473 Liters/Pint
24 = Conversion factor: 24 Hours/Day

Demand savings are derived from the Navigant Demand Impact Model.[2]

Measure Name	ΔkWh	ΔkW
Early Retirement Dehumidifier	320.3	0.07

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:

Coincidence factors are derived from the Navigant Demand Impact Model.

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 : 35 pints per day was the average capacity for units turned in at the Cape Light Compact's May 2010 event.
2 : Navigant Consulting (2018). Demand Impact Model Update.

2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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

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)	E19B1a123
Early Retirement CW Gas DHW & Elec Dryer	Income Eligible Coordinated Delivery (IE_CD)	E19B1a124
Early Retirement CW Elec DHW & Gas Dryer	Income Eligible Coordinated Delivery (IE_CD)	E19B1a125
Early Retirement CW Oil DHW & Elec Dryer	Income Eligible Coordinated Delivery (IE_CD)	E19B1a126
Early Retirement CW Gas DHW & Gas Dryer	Income Eligible Coordinated Delivery (IE_CD)	E19B1a127
Early Retirement CW Propane DHW & Elec Dryer	Income Eligible Coordinated Delivery (IE_CD)	E19B1a128

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	0.16	0.00
Early Retirement CW Gas DHW & Elec Dryer	260.5	0.07	1.54
Early Retirement CW Elec DHW & Gas Dryer	375	0.10	0.76
Early Retirement CW Oil DHW & Elec Dryer	260.5	0.07	1.54
Early Retirement CW Gas DHW & Gas Dryer	35.7	0.01	2.31
Early Retirement CW Propane DHW & Elec Dryer	260.5	0.07	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	0.49	0.52

In-Service Rates:

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

Realization Rates:

Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

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)	E19B1a037
Freezer Replacement (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a114

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 Name	Core Initiative	ΔkWh	ΔkW
Freezer Replacement (Single Family)	IE_CD	239	0.03
Freezer Replacement (Multifamily)	IE_CD	158	0.02

Baseline Efficiency:

The baseline efficiency case for both the replaced and baseline new freezer is represented by the existing freezer. It is assumed that low-income customers would replace their freezers with a used inefficient unit.

High Efficiency:

The high efficiency case is a new high efficiency freezer.

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	0.91	0.68
Freezer Replacement (Multifamily)	IE_CD	All	1.00	1.00	n/a	1.00	1.00	0.91	0.68

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 Navigant Demand Impact Model.

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	$26.61	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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances.
Energy_Star_2018_Consumer_Appliance_Calc

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)	E19B1a115

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the following algorithms and assumptions:
$\Delta kWh = ((kWh_{pre} - kWh_{ES}) \times RUL/EUL) + ((kWh_{std}+kWh_{used}/2 - kWh_{ES})xEUL-RUL/EUL))xF_{occ}$
$\Delta kW = \Delta kWhxkW/kWh$

Where:
kWh_{pre}= Annual kWh consumption of existing equipment. Value is based on metering or AHAM database. The default value is 874 kWh.
kWh_{ES} = Annual kWh consumption of new ENERGY STAR qualified refrigerator or freezer. This is from the nameplate on the new unit. The default value is 358 kWh.
STD = Average annual consumption of equipment meeting federal standard: Calculated by dividing the 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	0.79	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 demand allocation methodology described the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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)	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	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	0.79	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	0.00	0.00	0.00	1.00

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	$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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances.
Energy_Star_2018_Consumer_Appliance_Calc
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

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)	E19B1a039
Appliance Removal (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a113

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 Name	ΔkWh	ΔkW
Appliance Removal (Single Family)	874	0.11
Appliance Removal (Multifamily)	874	0.11

Baseline Efficiency:

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

High Efficiency:

The high efficiency case assumes no replacement of secondary unit.

Measure Life:

The measure life is 5 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Appliance Removal (Single Family)	IE_CD	All	5	n/a	n/a	5
Appliance Removal (Multifamily)	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	EUL	OYF	RUL	AML
Appliance Removal (Single Family)	IE_CD	All	5	n/a	n/a	5
Appliance Removal (Multifamily)	IE_CD	All	5	n/a	n/a	5

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Appliance Removal (Single Family)	IE_CD	All	0.00	0.00	0.00	1.00
Appliance Removal (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
Appliance Removal (Single Family)	IE_CD	All	$0.00	$0.00	Varies by PA	$0.01	$0.00	$0.00
Appliance Removal (Multifamily)	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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Massachusetts Common Assumption.
4 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

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
TLC Kit (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a278
TLC Kit (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a052
Participant/TLC Kit, Gas	Income Eligible Coordinated Delivery (IE_CD)	G19B1a001
Participants (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a001
Participants (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a277

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 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	0.58	0.86
TLC Kit (Multifamily)	IE_CD	All	1.00	1.00	n/a	1.00	1.00	0.58	0.86

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described the Demand Impact Model. [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

Endnotes:

1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation
CADMUS_2012_Single_Family_Low_Income_Impact_Eval
2 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Massachusetts Common Assumption.
4 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

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)	E19B1a056
Air Sealing, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a018
Air Sealing, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a057
Air Sealing, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a058

Algorithms for Calculating Primary Energy Impact:

Eversource and CMA:

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 and CMA:

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

TMY3 City	HDD	CDH
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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 demand allocation methodology described in the Demand Impact Model.[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	$77.73	$0.00	Varies by PA	$0.01	$0.00	$0.00
Air Sealing, Gas (Multifamily)	IE_CD	All	$77.73	$0.00	$0.00	$0.00	Varies by PA	$0.08
Air Sealing, Oil (Multifamily)	IE_CD	All	$77.73	$0.00	$0.00	$0.00	$0.00	$0.00
Air Sealing, Other (Multifamily)	IE_CD	All	$77.73	$0.00	$0.00	$0.00	$0.00	$0.00

Endnotes:

1 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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

2.9. 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.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Insulation, Electric (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a059
Insulation, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a019
Insulation, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a060
Insulation, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a061

Algorithms for Calculating Primary Energy Impact:

Eversource and CMA:

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 and CMA:

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

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 demand allocation methodology described in the Demand Impact Model.[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	$101.01	$0.00	Varies by PA	$0.01	$0.00	$0.00
Insulation, Gas (Multifamily)	IE_CD	All	$101.01	$0.00	$0.00	$0.00	Varies by PA	$0.08
Insulation, Oil (Multifamily)	IE_CD	All	$101.01	$0.00	$0.00	$0.00	$0.00	$0.00
Insulation, Other (Multifamily)	IE_CD	All	$101.01	$0.00	$0.00	$0.00	$0.00	$0.00

Endnotes:

1 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
8 : 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

2.10. 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)	E19B1a002
Weatherization, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a003
Weatherization, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a004
Weatherization, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a002
Air Sealing, Electric (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a005
Air Sealing, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a006
Air Sealing, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a007
Air Sealing, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a003
Insulation, Electric (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a008
Insulation, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a009
Insulation, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a010
Insulation, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a004
Weatherization, Electric (Multi Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a053
Weatherization, Oil (Multi Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a054
Weatherization, Other (Multi Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a055

Algorithms for Calculating Primary Energy Impact:

Unit savings are per home and deemed based on study results.[1] kW savings are calculated using the demand impact model.[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:

Coincidence factors are estimated using the demand allocation methodology described in the Navigant Demand Impact Model (2012).[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	$ 97.82		Varies by PA	$0.01		
Weatherization, Oil (Multi Family)	IE_CD	CLC	$ 97.82		Varies by PA	$0.01		
Weatherization, Other (Multi Family)	IE_CD	CLC	$ 97.82		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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

3 : Massachusetts Common Assumption.
4 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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
Demand Circulator (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a039
Boiler Reset Control, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a038
Custom HVAC (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a119
Custom Hot Water (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a130
Custom Process (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a131
Custom Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a132
Heating System Retrofit, Heat Pump (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a015

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	1.00	n/a	0.80	n/a	n/a	n/a	n/a
Gas Measures	IE_CD	Columbia	1.00	n/a	0.96	n/a	n/a	n/a	n/a
Gas Measures	IE_CD	Eversource	1.00	n/a	1.05	n/a	n/a	n/a	n/a
Gas Measures	IE_CD	Liberty	1.00	n/a	0.96	n/a	n/a	n/a	n/a
Gas Measures	IE_CD	National Grid	1.00	n/a	0.75	n/a	n/a	n/a	n/a
Gas Measures	IE_CD	Unitil	1.00	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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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	0.34	0.21

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]

Measure Name	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		

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

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 Control, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a016
Boiler Reset Control, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a016

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)	E19B1a011
Heating System Retrofit, Boiler, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a012
Heating System Retrofit, Boiler, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a005

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 furnace.

High Efficiency:

The high efficiency case is the new efficient furnace.

Measure Life:

The measure life is 20 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System Retrofit, Boiler, Oil (Single Family)	IE_CD	All	20	n/a	n/a	20
Heating System Retrofit, Boiler, Other (Single Family)	IE_CD	All	20	n/a	n/a	20
Heating System Retrofit, Boiler, Gas (Single Family)	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}
Heating System Retrofit, Boiler, Oil (Single Family)	IE_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler, Other (Single Family)	IE_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Heating System Retrofit, Boiler, 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 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, Oil (Single Family)	IE_CD	All	0.00	0.00	0.00	1.00

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heating System Retrofit, Boiler, Other (Single Family)	IE_CD	All	0.00	0.00	0.00	1.00
Heating System Retrofit, Boiler, Gas (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 - Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil/Propane

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, Propane (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a272
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a273

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a model developed to estimate the savings associated with the displacement of exiting heating (and cooling) systems, using the following key assumptions[1]:

Average Home Heating load = 68.4 MMBTUs[2]
Electric Resistance Switchover Temperature = 5[3]F
Capacity of new Heat Pump = 4 Tons
Average Annual Home Cooling Load: 13.1 MMBtus
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
Central Ducted Heat Pump Fully Displacing Existing Furnace, Propane	86.7	-8.15	-6,278
Central Ducted Heat Pump Fully Displacing Existing Furnace, Oil	86.7	-8.15	-6,278

Baseline Efficiency:

For propane the baseline is an inefficient existing furnace at 78% AFUE.[4] For oil the baseline is an inefficient existing furnace at 78% AFUE.[5]
For existing air conditioning the baseline is room/window A/C 8 EER, Central A/C 10 SEER/8.5 EER.[6]

High Efficiency:

The high efficiency case is a new 5 ton 18 SEER/9.6 HSPF ducted central heat pump.

Measure Life:

The measure life is 16 years.

Measure Name	Core Initiative	PA	EUL[7]	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	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.34	0.21

In-Service Rates:

All installations have 100% in-service 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:

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

Endnotes:

1 : Navigant Consulting (2019). Energy Optimization Study Update. 2019_Navigant_EO_Update
2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Navigant Consulting (2018). Baseline Study Saturation Results 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 Results 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : 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

2.15. HVAC - Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil/Propane

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, Propane (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a268
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a269

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on a model developed to estimate the savings associated with the displacement of exiting heating (and cooling) systems, using the following key assumptions[1]:

Average Home Heating load = 68.4 MMBTUs[2]
Switchover Temperature = 15[3]F(Propane), 30^{o}F Degrees (Oil)
Capacity of new Heat Pump = 2.5 Tons
Average Annual Home Cooling Load: 13.1 MMBtus
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Saved MMBtu	ΔkW	ΔkWh
Central Ducted Heat Pump Partially Displacing Existing Furnace, Propane	76.5	-2.26	-6,378
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	42.1	-1.77	-3,814

Baseline Efficiency:

For propane the baseline is an existing inefficient furnace at 78% AFUE.[4] For propane the baseline is an inefficient furnace at 78% AFUE.[5]
For existing air conditioning the baseline is room/window A/C 8 EER, Central A/C 10 SEER/8.5 EER.[6]

High Efficiency:

The high efficiency case is a new efficient 2.5 ton 18 SEER/9.6 HSPF ducted central heat pump.

Measure Life:

Measure Name	Core Initiative	PA	EUL[7]	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, Propane	IE_CD	All	1.00	1.00	1.00	1.00	1.00	-0.09	0.21
Central Ducted Heat Pump Partially Displacing Existing Furnace, Oil	IE_CD	All	1.00	1.00	1.00	1.00	1.00	-0.12	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	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:

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

Endnotes:

1 : Navigant Consulting (2019). Energy Optimization Study Update. 2019_Navigant_EO_Update
2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation. Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Navigant Consulting (2018). Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 Results
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

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)	E19B1a044
Wi-Fi Thermostat, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a045
Wi-Fi Thermostat, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a047
Wi-Fi Thermostat, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a049
Wi-Fi Thermostat, AC Only (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a095
Wi-Fi Thermostat, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a096
Wi-Fi Thermostat, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a097
Wi-Fi Thermostat, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a014
Wi-Fi Thermostat, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a036

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] 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	0.10	

Measure Name	ΔkWh	ΔkW	Δ MMBtu
Wi-Fi Thermostat, Gas (Single Family)	18	0.03	3.11
Wi-Fi Thermostat, Oil (Single Family)	18	0.03	3.11
Wi-Fi Thermostat, Other (Single Family)	18	0.03	3.11
Wi-Fi Thermostat, Electric (AC Only) (Multifamily)	64	0.10	
Wi-Fi Thermostat, Gas (Multifamily)	18	0.03	3.11
Wi-Fi Thermostat, Oil (Multifamily)	18	0.03	3.11
Wi-Fi Thermostat, Other (Multifamily)	18	0.03	3.11

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	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	0.35	0.00
Wi-Fi Thermostat, Gas (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Wi-Fi Thermostat, Oil (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Other (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Electric (AC Only) (Multifamily)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Gas (Multifamily)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Oil (Multifamily)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	0.00
Wi-Fi Thermostat, Other (Multifamily)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.35	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 demand allocation methodology described the Demand Impact Model.[4]

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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.17. HVAC - DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil/Propane

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, Propane (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a270
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a271

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on calculations provided by evaluation consultants using the following assumptions[1]:

Average Home Heating load = 76.7 MMBTUs[2]
Oil Switchover Temperature = 30 degrees
Propane Switchover Temperature = 15 degrees
Tonnage of new Heat Pump = 2.5 Tons
Proportion of homes with air conditioning: 48% (room/window), 35% (central), 17% (none)[3]

Measure Name	Saved MMBtu Oil/Propane	ΔkW	ΔkWh
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	84.7	-2.37	-7,564
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil	49.7	-2.04	-4,339

Baseline Efficiency:

For oil the baseline efficiency case is a 75% AFUE boiler.[4] For propane the baseline is a 75% AFUE boiler.[5]

High Efficiency:

The high efficiency case is a new 20 SEER/12 HSPF ductless mini split heat pumps.

Measure Life:

Measure Name	Core Initiative	PA	EUL[6]	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	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Oil	IE_CD	All	1.00	1.00	n/a	n/a	n/a	n/a	n/a
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	IE_CD	All	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 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, Oil	IE_CD	All	0.00	0.00	0.00	1.00
DMSHP with Integrated Controls Partially Displacing Existing Boiler, Propane	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 : Navigant Consulting (2019). Energy Optimization Study Update. 2019_Navigant_EO_Update
2 : Navigant Consulting (2018) Home Energy Services (HES) Impact Evaluation (RES 34) Engineering Algorithm Workbook Ex Post Furnace Heating Load 2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Baseline Study Saturation Results
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : Agreed upon value with EEAC consultants.
5 : Agreed upon value with EEAC consultants.
6 : 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

2.18. 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)	E19B1a135
Duct Insulation, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a018
Duct Insulation, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a019
Duct Insulation, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a008

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	0.55	
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	0.34	0.21
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 demand allocation methodology described the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_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

2.19. 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)	IE_CD	E19B1a064
Duct Insulation, Gas (Multifamily)	IE_CD	G19B1a024
Duct Insulation, Oil (Multifamily)	IE_CD	E19B1a065
Duct Insulation, Other (Multifamily)	IE_CD	E19B1a066

Algorithms for Calculating Primary Energy Impact:

Eversource and CMA:

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 and CMA:

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: 0.13[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	0.34	0.17
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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 demand allocation methodology described the Demand Impact Model.[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

Measure Name	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, 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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.20. 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)	E19B1a067
Duct Sealing, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a023
Duct Sealing, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a068
Duct Sealing, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a069

Algorithms for Calculating Primary Energy Impact:

Eversource and CMA:

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 and CMA:

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	0.34	0.17
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

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 demand allocation methodology described the Demand Impact Model.[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 (Multifamily)	IE_CD	All	$1.04		Varies by PA	$0.01		

Measure Name	Core Initiative	PA	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per kWh	Annual $ per Therm	One-time $ per Therm
Duct Sealing, Gas (Multifamily)	IE_CD	All	$1.04				Varies by PA	$0.08
Duct Sealing, Oil (Multifamily)	IE_CD	All	$1.04					
Duct Sealing, Other (Multifamily)	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 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.21. 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:

Unit savings are deemed based on study results.[1] [2]

Measure Name	ΔkWh	ΔkW[3]	Δ MMBtu
Duct Sealing, Electric (Single Family)	442	0.34	
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	0.34	0.21
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 demand allocation methodology described the Demand Impact Model.[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	IE_CD	All	$6.21		Varies by PA	$0.01	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 : For Electric : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation.
2018_Navigant_HES_Impact_Evaluation
3 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.22. HVAC - Ductless Mini-Split Heat Pump (DMSHP)

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, SEER 18.0 HSPF 10, Displacing Electric Heat (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a266
DMSHP, SEER 20.0 HSPF 12, Displacing Electric Heat (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a267

Algorithms for Calculating Primary Energy Impact:

DMSHP unit savings are deemed based on the following algorithms and assumptions:
$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat} = [Tons \times 12kBtu/hr/Ton \times (1/SEER_{BASE} - 1/SEER_{EE}) \times HOURS_C] + [Tons \times 12kBtu/hr/Ton \times (1/HSPF_{BASE} - 1/HSPF_{EE}) \times HOURS_H]$
$\Delta kW = \max(\Delta kW_{cool}, \Delta kW_{heat})$
$\Delta kW_{cool} = \Delta kWh_{cool} \times$ Annual Maximum Demand Factor (cool)
$\Delta kW_{heat} = \Delta kWh_{heat} \times$ Annual Maximum Demand Factor (heat)

Where:
Unit = Installation of DMSHP system
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.

Savings for Residential Ductless Mini-Split Heat Pumps[1]

Measure Name	Energy Type	Average Capacity (tons)[2]	Average SEER[3]	Average HSPF[4]	Cooling Hours[5] Heating Hours[6]	ΔkWh	Annual Max Demand Factor[7]	ΔkW
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat (Single Family)	Electric	1.78	22.2	11.5	218 (cool) 1,117 (heat)	5,039	0.001660 (cool) 0.000438 (heat)	2.163
DMSHP, SEER 20.0 HSPF 12, Displacing Electric Heat (Single Family)	Electric	1.10	25.9	12.8	218 (cool) 1,117 (heat)	3,265.4	0.001660 (cool) 0.000438 (heat)	1.395

Baseline Efficiency:

The baseline is a code-compliant, 2.2-ton, SEER 15.0 DMSHP system.[8] For displacement of electric heat, the equivalent HSPF for electric resistance heat is assumed to be 3.4.[9]

High Efficiency:

The high efficiency case is a 2.2-ton, SEER 19.5, HSPF 10.6 or 1.1-ton, SEER 25.9, HSPF 12.8 DMSHP system, based on the average capacity and efficiency levels of systems rebated in the previous calendar year.

Measure Life:

The measure life is based on evaluation results.[10]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat (Single Family)	IE_CD	All	18	N/A	N/A	18
DMSHP, SEER 20.0 HSPF 12, Displacing Electric Heat (Single Family)	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, SEER 18.0 HSPF 10, Displacing Electric Heat (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.022	0.62
DMSHP, SEER 20.0 HSPF 12, Displacing Electric Heat (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.027	0.62

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.[11]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
DMSHP, SEER 18.0 HSPF 10, Displacing Electric Heat (Single Family)	IE_CD	All	0.0%	0.0%	0.0%	100.0%
DMSHP, SEER 20.0 HSPF 12, Displacing Electric Heat (Single Family)	IE_CD	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, SEER 18.0 HSPF 10, Displacing Electric Heat (Single Family)	IE_CD	All	$283.39	$0.00	Varies by PA	$0.005	N/A	N/A

DMSHP, SEER 20.0 HSPF 12, Displacing Electric Heat (Single Family)	IE_CD	All	$283.39	$0.00	Varies by PA	$0.005	N/A	N/A

Endnotes:

1 : The calculation of unit savings can be found in MA PAs' 2019 Electric Heating and Cooling Savings Workbook (2019). 2019_MA_PAs_Electric_HVAC_Calculations
2 : Average capacity (tons) of heat pump units rebated in the full calendar year preceding the year in which this eTRM is published.
3 : Average SEER of heat pump units rebated in the full calendar year preceding the year in which this eTRM is published.
4 : Average HSPF of heat pump units 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 : 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
7 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
8 : Navigant Consulting (2018). Ductless Mini-Split Heat Pump Survey.
Navigant_2018_DMSHP_Survey
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 : Coincidence factors obtained from Navigant Consulting (2018). Demand Impact Model Update (for Ductless Mini Split Heat Pumps (heating and cooling)). The calculation of coincidence factors combined for heating and cooling can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018). 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.23. 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)	E19B1a013
Heating System Retrofit, Furnace, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a014
Heating System Retrofit, Furnace, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a006

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	0.09
Heating System Retrofit, Furnace, Other (Single Family)	Propane	20.7	172	0.11
Heating System Retrofit, Furnace, Gas (Single Family)	Gas	20.7	172	0.11

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 18 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heating System Retrofit, Furnace, Oil (Single Family)	IE_CD	All	18	n/a	n/a	18
Heating System Retrofit, Furnace, Other (Single Family)	IE_CD	All	18	n/a	n/a	18
Heating System Retrofit, Furnace, Gas (Single Family)	IE_CD	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}
Heating System Retrofit, Furnace, Oil (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Heating System Retrofit, Furnace, Other (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Heating System Retrofit, Furnace, Gas (Single Family)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

Coincidence factors are estimated using the demand allocation methodology described in the Navigant Consulting Demand Impact Model updated in 2018.[4]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heating System Retrofit, Furnace, Oil (Single Family)	IE_CD	All	0%	0%	0%	100%
Heating System Retrofit, Furnace, Other (Single Family)	IE_CD	All	0%	0%	0%	100%
Heating System Retrofit, Furnace, Gas (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.

Measure Name	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 (Single Family)	IE_CD	All	$310.82		Varies by PA	$0.01		
Heating System Retrofit, Furnace, Other (Single Family)	IE_CD	All	$310.82		Varies by PA	$0.01		
Heating System Retrofit, Furnace, 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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Furnace.
EPA_2009_Lifecycle_Cost_Estimate_for_ENERGY_STAR_Furnace
4 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.24. HVAC - Heat Pump - IE Multi-Family

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

Measure Description:

Installation of a custom 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)	E19B1a274
Custom Heat Pumps, Displacing Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a275
Custom Heat Pumps, Displacing Propane (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a276

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 existing site conditions.

High Efficiency:

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:

Coincidence factors for replacing electric baseboard are derived from the Demand Impact Model.[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			Varies by PA	$0.01		
Custom Heat Pumps, Displacing Oil (Multifamily)	IE_CD	All			Varies by PA	$0.01		
Custom Heat Pumps, Displacing Propane (Multifamily)	IE_CD	All			Varies by PA	$0.01		

Endnotes:

1 : Navigant (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
2 : 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

2.25. 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)	G19B1a020
Heating System Retrofit, Furnace, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a021
Heating System, Commercial Boiler (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a022

Algorithms for Calculating Primary Energy Impact:

Eversource and CMA:

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 and CMA:

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

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 is determined based on the type of heating equipment installed. For boilers it is 75% AFUE and for furnaces it is 78% AFUE.

High Efficiency:

The high efficiency case is characterized by the rated efficiency ($AFUE_{EE}$) of the new high efficiency furnace or boiler.

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

Measure Name	Program	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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	$118.10				Varies by PA	$0.08
Heating System Retrofit, Furnace	IE_CD	All	$118.10				Varies by PA	$0.08
Heating System Retrofit, Commercial Boiler	IE_CD	All	$118.10				Varies by PA	$0.08

Endnotes:

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

2.26. 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), Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a026
Pipe Wrap (Heating), Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a137
Pipe Wrap (Heating), Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a073

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

Measure Name	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), 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

2.27. 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)	E19B1a040
Programmable Thermostat, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a041
Programmable Thermostat, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a042
Programmable Thermostat, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a043
Programmable Thermostat, Electric (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a092
Programmable Thermostat, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a093
Programmable Thermostat, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a094
Programmable Thermostat, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a012
Programmable Thermostat, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a034

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results. The single family[1] and multifamily[2] savings came from different studies. The single family study only included savings for thermostats in oil heated homes and those savings were assumed to be the same for the gas and propane heated homes. The multifamily study

only included savings for thermostats in gas heated homes and those savings were assumed to be the same for oil and propane heated homes.

Measure Name	ΔkWh	ΔkW[3]	ΔMMBtu
Programmable Thermostat, Electric (Single Family)	330	0.24	
Programmable Thermostat, Gas (Single Family)			3.1
Programmable Thermostat, Oil (Single Family)			3.1
Programmable Thermostat, Other (Single Family)			3.1
Programmable Thermostat, Electric (Multifamily)	257	0.19	
Programmable Thermostat, Gas (Multifamily)			2.26
Programmable Thermostat, Oil (Multifamily)			2.26
Programmable Thermostat, Other (Multifamily)			2.26

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 15 years.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Programmable 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}
Programmable Thermostat, Electric (Single Family)	IE_CD	All	1.00	1.00	n/a	1.00	1.00	0.00	0.43

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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 demand allocation methodology described the Demand Impact Model.[5]

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.[6] 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 : 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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
4 : Environmental Protection Agency (2010). Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat.
EPA_2010_Lifecycle_Cost_Estimate_for_ENERGY_STAR_Programmable_Thermostats
5 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_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

2.28. 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)	E19B1a051
Window AC Replacement (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a116

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results except for National Grid's multifamily measure.[1] kW savings are derived from the Navigant Demand Impact Model.[2]

Measure Name	Core Initiative	PA	ΔkWh	ΔkW
Window AC Replacement (Single Family)	IE_CD	All	113	0.18
Window AC Replacement (Multifamily)	IE_CD	Eversource, Unitil, CLC	113	0.18

National Grid's multifamily unit savings are calculated using the following algorithms and assumptions:
ΔkWh = (Capacityexisting /EERexisting – Capacitynew/EERnew) * hours/1000
ΔkW = (Capacityexisting/EERexisting – Capacitynew/EERnew) /1000

Where:
Capacityexisting = size of existing unit in BTUs/hour
Capacitynew = size of new unit in BTUs/hour
EERexisting = 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	0.33	0.00
Window AC Replacement (Multifamily)	IE_CD	All	1.00	1.00	n/a	1.00	1.00	0.33	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 demand allocation methodology described the Demand Impact Model.[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
2 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : 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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.29. 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)	E19B1a029
Faucet Aerator, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a030 G19B1a010
Faucet Aerator, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a031
Faucet Aerator, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a032
Faucet Aerator, Electric (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a089
Faucet Aerator, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a030
Faucet Aerator, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a090
Faucet Aerator, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a091

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on separate single family[1] and multifamily[2] evaluation study results. kW savings are derived from the Navigant Demand Impact Model.[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

Measure Name	ΔkWh	ΔkW	Δ MMBtu
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	0.81
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:

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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

2.30. 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)	E19B1a017
Heat Pump Water Heaters (50 gallon) (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a079

Algorithms for Calculating Primary Energy Impact:

Water Heating Load, electric homes in New England =2,346 kWh/year.[1]

Baseline consumption = 2,346 kWh / 0.92 UEF = 2,250 kWh/year
Efficient consumption = 2,346 kWh / 2.45 UEF = 957.5 kWh/year

Heat pump water heaters transfer heat from their surroundings to water inside the water heater tank. Operation of HPWHs has an impact on space-conditioning loads because heat generated by the heating system is transferred from the conditioned space to the water tank. This impact is dependent on the HPWH's location (fully conditioned or semi-conditioned spaces), home insulation and sealing, thermostat location and set point, hot-water usage, and efficiency of home heating system. An HPWH impact study prepared in 2017 for the electric PAs of Massachusetts estimated the secondary impacts of HPWH on electric and gas consumption. This study estimated that 4.8% of the electric savings from HPWH would be lost due to increased electric consumption for heating.

kWh Savings = 1,592 kWh/year * (1-4.8%) = 1,516 kWh/year.
kW savings are derived from the Navigant Demand Impact Model.[2]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
Heat Pump Water Heaters (50 gallon) (Single family)	1,516	0.100	-0.10 gas -0.5 oil -0.07 propane
Heat Pump Water Heaters (50 gallon) (Multifamily)	1,516	0.100	-0.10 gas -0.5 oil -0.07 propane

Baseline Efficiency:

The baseline efficiency case is a 50-gallon, medium draw pattern, electric resistance storage water heater with a UEF of 0.92.

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.[3]

Measure Life:

The measure life is 13 years.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Heat Pump Water Heaters (50 gallon)	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 Heaters (50 gallon)	IE_CD	All	1.00	1.00	1.00	1.00	1.00	0.41	1.00

In-Service Rates:

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

Realization Rates:

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

Coincidence Factors:

Coincidence factors are based on evaluation results.[5] Winter coincidence equal to 1 since gross kW savings are equal to winter peak demand savings.

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Heat Pump Water Heaters (50 gallon) (Single family)	IE_CD	All	0.00	0.00	0.00	1.00
Heat Pump Water Heaters (50 gallon) (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.[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
Heat Pump Water Heaters (50 gallon) (Single family)	IE_CD	All	$41.28	$0.70				
Heat Pump Water Heaters (50 gallon) (Multifamily)	IE_CD	All	$41.28	$0.70				

Endnotes:

1 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
2 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : Energy Star is 2.0 UEF but no models exist that the efficiency level. Lowest available if 2.45 UEF.
4 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
5 : Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo
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

2.31. 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)	E19B1a025
Low-Flow Showerhead, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a026
Low-Flow Showerhead, Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a027
Low-Flow Showerhead, Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a028
Low-Flow Showerhead, Electric (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a080
Low-Flow Showerhead, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a081
Low-Flow Showerhead, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a082
Low-Flow Showerhead, Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a011
Low-Flow Showerhead, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a031

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1] [2]

Measure Name	ΔkWh	ΔkW[3]	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 7 years.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead	IE_CD	All	7	n/a	n/a	7

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	0.81
Low-Flow Showerhead, Gas (Single Family)	IE_CD	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
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	0.81
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:

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : The Cadmus Group (2012). Massachusetts Low-Income Multifamily Initiative Impact Evaluation.
CADMUS_2015_Low_Income_Multifamily_Impact_Evaluation
7 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.32. 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)	E19B1a083
Low-Flow Showerhead with TSV, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a084
Low-Flow Showerhead with TSV, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a085
Low-Flow Showerhead with TSV, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a032

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on engineering analysis.[1]

Measure Name	ΔkWh	ΔkW[2]	ΔMMBtu
Low-Flow Showerhead with TSV, Electric (Multifamily)	335.0	0.08	
Low-Flow Showerhead with TSV, Gas (Multifamily)			1.66
Low-Flow Showerhead with TSV, Oil (Multifamily)			1.88
Low-Flow Showerhead with TSV, Other (Multifamily)			1.66

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 7 years. [3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead with TSV (Multifamily)	IE_CD	All	7	n/a	n/a	7

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	0.81
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:

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[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.[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 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 : 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 : MA Common Assumptions.
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 : 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 - 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)	E19B1a022
Pipe Wrap (Water Heating), Gas (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a009
Pipe Wrap (Water Heating), Oil (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a023
Pipe Wrap (Water Heating), Other (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a024
Pipe Wrap (Water Heating), Electric (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a070
Pipe Wrap (Water Heating), Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a025
Pipe Wrap (Water Heating), Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a071
Pipe Wrap (Water Heating), Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a072

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]

Measure Name	ΔkWh	ΔkW^2	Δ MMBtu
Pipe Wrap (Water Heating), Electric	41.0	0.01	
Pipe Wrap (Water Heating), Gas			0.40

Measure Name	ΔkWh	ΔkW^2	Δ MMBtu
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 demand allocation methodology described the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2.34. 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)	E19B1a086
Thermostatic Shut-off Valve, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a033
Thermostatic Shut-off Valve, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a087
Thermostatic Shut-off Valve, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a088

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 (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 7 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Thermostatic Shut-off Valve (Multifamily)	IE_CD	All	7	n/a	n/a	7

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	0.81
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:

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
3 : MA Common Assumptions.
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

2.35. 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
On Demand Water Heater, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a027
On Demand Water Heater, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a074
On Demand Water Heater, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a075
Indirect Water Heater, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a028
Indirect Water Heater, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a076
Stand Alone Water Heater, Gas (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	G19B1a029
Stand Alone Water Heater, Oil (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a077
Stand Alone Water Heater, Other (Multifamily)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a078

Algorithms for Calculating Primary Energy Impact:

Eversource and CMA:

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 and CMA:

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

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 with an energy factor of 0.575.

High Efficiency:

The high efficiency case includes the new efficient water heater with an Energy Factor > 0.60.

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, Gas (Multifamily)	IE_CD	All	0.00	0.00	0.00	1.00
Water Heater, Oil (Multifamily)	IE_CD	All	0.00	0.00	0.00	1.00
Water Heater, Other (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
Water Heater, Gas (Multifamily)	IE_CD	All	$1.19				Varies by PA	$0.08
Water Heater, Oil (Multifamily)	IE_CD	All	$1.19					
Water Heater, 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 : 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

2.36. 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)	E19B1a118

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

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
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

2.37. 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)	E19B1a120

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

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 5 years.[2]

Other Resource 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	0.81	0.92	0.92	0.92	1.00	1.00

In-Service Rates:

In-service rates are based on consumer surveys, as found in the referenced study.[3]

Realization Rates:

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[4]

Coincidence Factors:

Summer and winter coincidence factors are based on referenced study.[5]

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 : Massachusetts Common Assumption
3 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
4 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. 2019_NMR_APSMeteringReport_Revised
5 : NMR Group, Inc. (2019). Advanced Power Strip Metering Study. 2018_NMR_APS_Metering_Report

2.38. 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)	E19B1a134

Algorithms for Calculating Primary Energy Impact:

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

Where:
kWrated = Rated kW of connected equipment. See for default rated kW by connected equipment type.
Hours = Operating hours of the connected equipment: default of 8,760 hours
SAVE = Percent savings factor for the connected equipment. See table below for values.

Vending Machine and Cooler Controls Savings Factors[1]

Equipment Type	kWRATED	SAVE (%)	ΔkW	ΔkWh
Refrigerated Beverage Vending Machines	0.40	46	0.184	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	0.00	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 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 and Industrial Efficiency Measures

3.1. Appliance - Refrigerator

Measure Code	COM-A-RR-MF
Market	Commercial
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 (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a088

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the following algorithms and assumptions:
$\Delta kWh = ((kWh_{pre} - kWh_{ES}) \times RUL/EUL) + ((kWh_{std}+kWh_{used}/2 - kWh_{ES}) \times EUL-RUL/EUL)) \times F_{occ}$
$\Delta kW = \Delta kWh \times kW/kWh$

Where:
kWh_{pre}= Annual kWh consumption of existing equipment. Value is based on metering or AHAM database. The default value is 874 kWh.
kWh_{ES} = Annual kWh consumption of new ENERGY STAR qualified refrigerator or freezer. This is from the nameplate on the new unit. The default value is 358 kWh.
kWh_{STD} = Average annual consumption of equipment meeting federal standard: Calculated by dividing the kWh_{ES} by 0.9 (i.e., the Energy Star units are assumed to be 10% more efficient than the kWh_{std} units). The default value is 398 kWh.
kWh_{used} = Average annual consumption of used equipment. Default value is 475 kWh.[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	F_{occ}
0 occupants	1.00
1 occupant	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 efficient refrigerator. The manufacturer and model number are 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 (Residential End Use)	CI_RETRO	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 (Residential End Use)	CI_RETRO	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 demand allocation methodology described the Demand Impact Model.[6]

Impact Factors for Calculating Net Savings:

Net-to-Gross values are based on evaluation results.[7]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Refrigerator (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

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
Refrigerator (Residential End Use)	CI_RETRO	All	$20.10	$0.00	$0.00	$0.00	$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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
7 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation
8 : 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

3.2. 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 (Turnkey)	C&I Existing Buildings Retrofit (CI_RETRO)	E19C2a116
Refrigerator Recycling (Turnkey)	C&I Existing Buildings Retrofit (CI_RETRO)	E19C2a117

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed and reflect the corresponding Residential product offering. For full detail, please reference the Residential measure savings assumptions (measure code RES-A-RFR).

Measure Name	kW	kWh
Freezer Recycling (Turnkey)	0.14	769
Refrigerator Recycling (Turnkey)	0.18	1,027

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 8 years.

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Freezer/Refrigerator Recycling (Turnkey)	CI_RETRO	All	8	n/a	n/a	8

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	0.68	0.68	0.68	0.68	0.79	0.65
Refrigerator Recycling (Turnkey)	CI_RETRO	All	1.00	0.88	0.88	0.88	0.88	0.79	0.65

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.

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	0.940

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

3.3. 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
Building Operator Certification, Gas	C&I Existing Building Retrofit (CI_RETRO)	G19C2a001
Building Operator Certification Plus, Gas	C&I Existing Building Retrofit (CI_RETRO)	G19C2a002
Building Operator Certification, Electric	C&I Existing Building Retrofit (CI_RETRO)	E19C2a028
Building Operator Certification Plus, Electric	C&I Existing Building Retrofit (CI_RETRO)	E19C2a025

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 on 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)	E19C2a059
Air Sealing, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a060
Air Sealing, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a111
Air Sealing, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a055

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the following algorithms and assumptions:

$kWh = (Vol \times ACH \times 0.018 \times HDD \times 24 / \eta_{heating}) / 3{,}413$
$MMBtu = (Vol \times ACH \times 0.018 \times HDD \times 24 / \eta_{heating}) / 1{,}000{,}000$
$kW = kWh \times kW/kWh$

Where:
Vol = [ft3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
ACH = [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)
HDD = Heating degree-days, base 60 from TMY3 weather data. See table below.
$\eta_{heating}$ = [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	1.00	n/a	0.86	0.86	0.00	0.43
Air Sealing, Oil (Residential End Use)	CI_RETRO	All	1.00	1.00	0.86	n/a	n/a	n/a	n/a
Air Sealing, Other (Residential End Use)	CI_RETRO	All	1.00	1.00	0.86	n/a	n/a	n/a	n/a
Air Sealing, Gas (Residential End Use)	CI_RETRO	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 based on evaluation results.[3]

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Demand Impact Model.[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	0.21	0.13	0.17	1.09

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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_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.
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
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. 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)	E19C1a007
Compressed Air – Air Nozzle	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b007

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 efficiency 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	0.80	0.54

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 CI_EQUIP	All	0.40	0.03	0.03	0.66

Non-Energy Impacts:

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

Endnotes:

1 : Energy & Resource Solutions (2005). Measure Life Study. ERS_2005_Measure_Life_Study
2 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.6. 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 Buildings & Major Renovations (CI_NB&MR)	E19C1a003
Compressed Air - High Efficiency Air Compressors	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b003

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 efficiency 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	1.17	0.98

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 study results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Compressed Air - High Efficiency Air Compressor	CI_NB&MR	All	0.40	0.03	0.03	0.66
Compressed Air - High Efficiency Air Compressor	CI_EQUIP	All	0.23	0.09	0.00	0.86

Non-Energy Impacts:

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

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

3.7. 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)	E19C1a005
Compressed Air – Low Pressure Drop Filters	C&I Existing Building Retrofit (CI_RETRO)	E19C2a004
Compressed Air – Low Pressure Drop Filters	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b005

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = (Quantity) \times (HP_{comp}) \times (0.7457) \times (\%savings) \times (Hours)$
$\Delta kW = (Quantity) \times (HP_{comp}) \times (0.7457) \times (\%savings)$

Where:
ΔkWh = Energy savings
ΔkW = Demand savings
Quantity = Number of filters installed. Site specific.
HP_{comp} = Average compressor load. Site specific.
0.7457 = Conversion from HP to kW
% Savings = Percent change in pressure drop. Site specific.
Hours = Annual operating hours of the lower pressure drop filter. Site specific.

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	0.80	0.54
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	0.88	0.69

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	0.40	0.03	0.03	0.66
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:

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

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

3.8. 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)	E19C1a004
Compressed Air - Refrigerated Air Dryers	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b004

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	1.17	0.98

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]

Non-Energy Impacts:

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

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

3.9. 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)	E19C1a006
Compressed Air – Zero Loss Condensate Drains	C&I Existing Building Retrofit (CI_RETRO)	E19C2a005
Compressed Air – Zero Loss Condensate Drains	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b006

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = (CFM_{pipe}) \times (CFM_{save}) \times (Save) \times (Hours)$
$\Delta kW = (CFM_{pipe}) \times (CFM_{save}) \times (Save)$

Where:
ΔkWh = Energy Savings
ΔkW = Demand savings
CFM_{pipe} = CFM capacity of piping. Site specific.
CFM_{save} = Average CFM saved per CFM of piping capacity: 0.049
Save = Average savings per CFM: 0.241 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 Rates[3] :

- 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 - Low Pressure Drop Filters	CI_NB&MR	All	0.40	0.03	0.03	0.66
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:

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

Endnotes:

1 : Based on Eversource (NSTAR) analysis assuming a typical timed drain settings discharge scenario.
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

3.10. Custom - C&I 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
HVAC Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a102
Hot Water Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a103
Lighting Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a104
Process Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a105
Other Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a110
Heating, Gas - Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a050
Process, Gas - Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a051
Water Heating, Gas - Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a052
Lighting, Interior - Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a053
Lighting, Exterior - Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a054

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:

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}
Lighting - Custom (Residential End Use)	CI_RETRO	National Grid	1.00	0.98	n/a	1.16	0.85	custom	custom
Lighting - Custom (Residential End Use)	CI_RETRO	Eversource	1.00	1.02	n/a	0.85	0.84	custom	custom
Lighting - Custom (Residential End Use)	CI_RETRO	CLC, Unitil	1.00	0.98	n/a	0.94	0.94	custom	custom
HVAC Custom (Residential End Use)	CI_RETRO	National Grid	1.00	0.75	n/a	0.70	0.67	custom	custom
HVAC Custom (Residential End Use)	CI_RETRO	Eversource	1.00	0.91	n/a	0.94	0.88	custom	custom
HVAC Custom (Residential End Use)	CI_RETRO	CLC, Unitil	1.00	0.88	n/a	0.88	0.85	custom	custom
Hot Water Custom (Residential End Use)	CI_RETRO	National Grid	1.00	0.68	n/a	0.96	0.82	custom	custom
Hot Water Custom (Residential End Use)	CI_RETRO	Eversource	1.00	1.00	n/a	0.92	0.92	custom	custom

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Hot Water Custom (Residential End Use)	CI_RETRO	CLC	1.00	0.91	n/a	0.92	0.92	custom	custom
Hot Water Custom (Residential End Use)	CI_RETRO	Unitil	1.00	1.08	n/a	1.00	1.00	custom	custom
All Gas - Custom	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: All PAs use realization rates from the large commercial custom lighting statewide impact evaluation completed in 2012.[1]
- HVAC: All PAs use realization rates from the large commercial custom HVAC impact evaluation completed in 2015.[2]
- Hot Water: National Grid RRs derived from the large commercial electric process evaluation.[3] Eversource and CLC energy RRs and all demand RRs based on Eversource (NSTAR) 2002–2004 small retrofit impact evaluations, Unitil RRs from Small Business program impact evaluation.[4]

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.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
All Measures - Custom (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

Non-Energy Impacts:

All non-energy impacts should be determined on a case-by-case basis.

Endnotes:

1 : KEMA (2012). Impact Evaluation of the 2010 Custom Lighting Installations. KEMA_2012_Custom_Lighting_Final_Report
2 : DNVGL_2015_Impact_Eval_Custom_HVAC_FINAL
3 : KEMA (2012). Impact Evaluation of 2010 Custom Process and Compressed Air Installations.

KEMA_2012_Custom_Process_and_CAIR_Report
4 : Summit Blue Consulting, LLC (2008). Multiple Small Business Services Programs Impact Evaluation 2007 – Final Report Update.
Summit_Blue_2008_Multiple_Small_Business_Service_Programs_Impact_Evaluation
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

3.11. 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
Compressed Air - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a043
Hot Water - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a044
HVAC - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a046
Lighting - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a052
Motors & VFD - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a053
Process - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a056
Refrigeration - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a057
Other - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a058
Retrocommissioning (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a113
Building Shell, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a028
Controls, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a029
Food Services, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a030
Heat Recovery, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a031
Heating, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a032
Other, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a033
Process, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a034

Measure Name	Core Initiative	BCR Measure ID
Steam Trap, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a035
Water Heating, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a036
Retrocommissioning, Gas - Custom (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a073

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 (not final as of 2019-21 planning). 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	0.75	n/a	n/a	n/a	n/a
All Custom, Gas	CI_RETRO	NGRID	1.00	n/a	0.91	n/a	n/a	n/a	n/a
All Custom, Gas	CI_RETRO	Columbia	1.00	n/a	0.84	n/a	n/a	n/a	n/a
All Custom, Gas	CI_RETRO	All Other	1.00	n/a	0.85	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 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 Columbia use PA specific results based on evaluation of PY2017 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:

PA specific results used for custom net-to-gross when the results meet required statistical criteria. If PA specific results are not precise enough, either a PA specific combined custom/prescriptive value or a combined statewide custom/prescriptive value for the given initiative will be applied.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
All Custom Gas, Turnkey	CI_RETRO	Eversource	0.20	0.002	0.00	0.81
All Custom Gas, Turnkey	CI_RETRO	National Grid	0.14	0.004	0.00	0.86
All Custom Gas, Turnkey	CI_RETRO	Columbia	0.08	0.58	0.00	1.50
All Custom Gas, Turnkey	CI_RETRO	All other	0.15	0.12	0.00	0.97
All Custom Electric, Turnkey	CI_RETRO	Eversource	0.17	0.02	0.08	0.92
All Custom Electric, Turnkey	CI_RETRO	National Grid	0.10	0.02	0.04	0.96
All Custom Electric, Turnkey	CI_RETRO	CLC	0.21	0.09	0.00	0.88
All Custom Electric, Turnkey	CI_RETRO	Unitil	0.14	0.02	0.06	0.94

Non-Energy Impacts:

All non-energy impacts should be determined on a case-by-case basis.

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. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.12. 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
Comprehensive Design - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a001
Compressed Air - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a002
Water Heating - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a009
HVAC - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a010
Lighting - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a013
Motors & VFD - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a024
Process - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a026
Refrigeration - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a027
CHP	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a028
Other - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a029
CHP	C&I Existing Building Retrofit (CI_RETRO)	E19C2a001
Comprehensive Retrofit - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a002
Compressed Air - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a003
HVAC - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a007
Lighting - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a008

Measure Name	Core Initiative	BCR Measure ID
Motors & VFD - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a019
Process- Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a024
Refrigeration - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a025
Water Heating - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a026
Other - Custom	C&I Existing Building Retrofit (CI_RETRO)	E19C2a027
Retrocommissioning	C&I Existing Building Retrofit (CI_RETRO)	E19C2a114
CHP	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b001
Compressed Air - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b002
HVAC - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b009
Lighting - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b012
Motors & VFD - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b023
Process - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b025
Refrigeration - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b026
Water Heating - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b027
Other - Custom	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b028
Building Shell, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a001
Comprehensive Design, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a002
Controls, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a003
Food Services, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a004
Heat Recovery, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a005
Heating, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a006
Other, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a007
Process, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a009
Water Heating, Gas - Custom	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a010

Measure Name	Core Initiative	BCR Measure ID
Building Shell, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a003
Controls, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a004
Food Services, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a005
Heat Recovery, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a006
Heating, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a007
Other, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a008
Ozonated Laundry, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a009
Process, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a010
Steam Trap, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a011
Water Heating, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a014
Steam Trap, Gas (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a071
Retrocommissioning, Gas - Custom	C&I Existing Building Retrofit (CI_RETRO)	G19C2a072
Food Services, Gas - Custom	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b001
Heat Recovery, Gas - Custom	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b002
Heating, Gas - Custom	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b003
Other, Gas - Custom	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b004
Process, Gas - Custom	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b005
Water Heating, Gas - Custom	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b006

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 (not final as of 2019-21 planning). 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] Dual baseline effects should be considered for retrofit projects.[3]

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}
Custom Gas, All	CI_NB&MR, CI_RETRO, CI_IP&EUL	NGRID	1	n/a	0.91	n/a	n/a	custom	custom
		Columbia	1	n/a	0.84	n/a	n/a	custom	custom
		Eversource	1	n/a	0.75	n/a	n/a	custom	custom
		Unitil, Liberty, Berkshire	1	n/a	0.85	n/a	n/a	custom	custom
Custom Electric, Non-Lighting	CI_NB&MR, CI_RETRO, CI_IP&EUL	NGRID	1	0.68	0.68	0.78	0.64	custom	custom
		Eversource	1	0.73	0.73	0.83	0.85	custom	custom
		CLC	1	0.78	0.78	0.76	0.61	custom	custom

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
		Unitil (Statewide)	1	0.71	0.71	0.8	0.74	custom	custom
Custom Electric, Lighting	CI_NB&MR, CI_RETRO, CI_IP&EUL	NGRID	1	0.96	0.96	1.02	0.93	custom	custom
		Eversource	1	1.03	1.03	0.85	0.79	custom	custom
		CLC	1	0.93	0.93	0.94	0.78	custom	custom
		Unitil (Statewide)	1	1	1	0.93	0.83	custom	custom
Comprehensive Design Analysis - Electric	CI_NB&MR, CI_RETRO, CI_IP&EUL	All	1	0.57	0.57	0.57	0.43	custom	custom
Comprehensive Design Analysis - Gas	CI_NB&MR, CI_RETRO, CI_IP&EUL	All	1	n/a	1.01	n/a	n/a	custom	custom
CHP - Custom	CI_NB&MR, CI_RETRO, CI_IP&EUL	Eversource	1	1.1	1.22	1.44	1.01	custom	custom
		NGRID	1	0.91	1.02	1.09	1.05	custom	custom
		Unitil	1	0.90	1.12	1.26	1.58	custom	custom

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: RRs based on evaluation of PY2014 projects.[5]
- Electric, Lighting & Non-Lighting: RRs based on evaluation of PY2017-PY2018 projects.[6]
- Gas (all): RRs based on evaluation of PY2017 projects.[7]

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 are taken from the 2018 Free-ridership and Spillover Study.[8] PA specific values are used when the results meet a threshold precision.[9]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
All Custom Electric	CI_NB&MR	Eversource	18.6%	0.1%	10.8%	92.2%
		National Grid	23.0%	1.9%	6.0%	84.9%
		CLC	20.1%	0.4%	9.8%	90.2%
		Unitil	20.1%	0.4%	9.8%	90.2%
	CI_EQUIP	Eversource	11.1%	0.0%	2.4%	91.3%
		National Grid	15.9%	2.2%	11.7%	98.1%
		CLC	12.6%	0.7%	5.4%	93.5%
		Unitil	12.6%	0.7%	5.4%	93.5%
	CI_RETRO	Eversource	17.1%	1.6%	7.7%	92.2%
		National Grid	9.7%	2.3%	3.6%	96.2%
		CLC	21.3%	9.4%	0.0%	88.2%
		Unitil	13.6%	2.0%	5.7%	94.1%
All Custom Gas	CI_NB&MR	Eversource	27.5%	0.0%	0.0%	72.5%
		National Grid	18.8%	0.0%	0.1%	81.2%
		All other PAs	20.8%	0.0%	0.1%	79.3%
	CI_EQUIP	Eversource	5.1%	0.1%	0.0%	95.0%
		All other PAs	17.0%	4.9%	0.0%	87.9%
	CI_RETRO	ES	19.6%	0.2%	0.0%	80.6%
		NGRID	14.0%	0.4%	0.0%	86.3%
		Columbia	8.0%	58.2%	0.0%	85.5%
		All other PAs	14.9%	11.8%	0.0%	85.5%

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.

Measure Name	Core Initiative	PA	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per KWh	Annual $ per Therm	One-time $ per Therm
Comprehensive Design	CI_NB&MR	All			$0.015		$(0.005)	
Compressed Air	CI_NB&MR	All			$0.030		n/a	
Food Service	CI_NB&MR	All			$0.227		$0.263	
HVAC	CI_NB&MR	All			$0.003		$0.00	
Lighting	CI_NB&MR	All			$0.009		n/a	
Process	CI_NB&MR	All			$0.013		$0.008	
Refrigeration	CI_NB&MR	All			$0.008		n/a	
Boilers	CI_NB&MR	All			n/a		$(0.008)	
Water Heating	CI_NB&MR	All			n/a		$0.00	
Compressed Air	CI_RETRO	All			$0.056		n/a	
HVAC	CI_RETRO	All			$0.024		n/a	
Lighting	CI_RETRO	All			$0.059		n/a	
Process	CI_RETRO	All			$0.056		n/a	
Refrigeration	CI_RETRO	All			$0.047		n/a	
CHP	CI_RETRO	All			$(0.015)		n/a	
Steam Traps	CI_RETRO	All			n/a		$1.350	

Endnotes:

1 : DNV GL (2017). Massachusetts Commercial Industrial Baseline Framework 2017_DNVGL_MA_Baseline_Framework
2 : Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-2. ERS_2005_Measure_Life_Study
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 : 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.
6 : 2020_DNVGL_Custom_Electric_Results_Memo
7 : 2020_DNVGL_Custom_Gas_Final_Report
8 : Tetra Tech (2015). National Grid, Eversource (NSTAR), Western Massachusetts Electric Company, Unitil, and Cape Light Compact 2013 Commercial and Industrial Programs Free-ridership and Spillover Study.
9 : As agreed in a conference call on 2/28 with Ralph, evaluation consultants, and the PAs: As a general guideline, we agree to use NTG values that meet the following criteria: at least 90% confidence/25% relative precision, OR at least 90% confidence/10% absolute precision. If neither of these criteria are met, or if we do not have a sample size greater than 10, we will consider applying results at a higher level of aggregation.

3.13. 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, Storage Daily Dispatch, Storage Targeted Dispatch, and Storage System and Performance, 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 Program Administrators also incentivize active demand reduction strategies during winter. The goal is to help promote winter resiliency by finding customers that can reduce electric usage during times of high winter system load.

The 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 Storage Targeted Dispatch 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 with a focus on the annual system peak hour.

The C&I Storage System and Performance offering provides increased performance incentives for C&I storage performance. Since storage does not impact customer comfort or operations, storage resources are expected to be available for daily dispatch to maximize their value.

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)	E19C2c001
Storage System and Performance, Summer	C&I Active Demand Reduction (CI_ADR)	E19C2c002
Storage Daily Dispatch	C&I Active Demand Reduction (CI_ADR)	E19C2c003

Measure Name	Core Initiative	BCR Measure ID
Storage Targeted Dispatch, Summer	C&I Active Demand Reduction (CI_ADR)	E19C2c004
Storage Targeted Dispatch, Winter	C&I Active Demand Reduction (CI_ADR)	E19C2c005
Custom	C&I Active Demand Reduction (CI_ADR)	E19C2c006
Winter Interruptible Load	C&I Active Demand Reduction (CI_ADR)	E19C2c007
Storage System and Performance, Winter	C&I Active Demand Reduction (CI_ADR)	E19C2c008

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 storage, both daily dispatch and targeted dispatch (summer and winter), 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.[1,2]

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.[3]

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:

Statewide Active Demand Reduction offerings are new in 2019, and have only been evaluated with regard to the summer peak realization rate (RR_{SP}). The realization rate for electric kWh (RR_E) is assumed to be equal to RR_{SP}. Unless otherwise noted below, 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.

For summer interruptible load, the summer 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.[4]

For daily dispatch storage, 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.[5]

For targeted dispatch storage, the summer peak realization rate is calculated as the evaluated average utility event load reduction as a percentage of the reported load reduction.[6] Winter targeted dispatch storage has not yet been evaluated, but is assigned the same realization rate as summer targeted dispatch storage until such time as evaluation results are available.

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	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Storage System and Performance, discharge (savings) Summer	CI_ADR	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Storage System and Performance, charge (consumption) Summer	CI_ADR	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Storage System and Performance, discharge (savings) Winter	CI_ADR	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Storage System and Performance, charge (consumption) Winter	CI_ADR	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Storage Daily Dispatch, discharge (savings)	CI_ADR	All	1.00	1.04	1.00	1.04	1.00	1.00	0.00
Storage Daily Dispatch, charge (consumption)	CI_ADR	All	1.00	1.04	1.00	1.04	1.00	0.00	0.00
Storage Targeted Dispatch, discharge (savings) Summer	CI_ADR	All	1.00	1.01	1.00	1.01	1.00	1.00	0.00
Storage Targeted Dispatch, charge (consumption) Summer	CI_ADR	All	1.00	1.01	1.00	1.01	1.00	0.00	0.00
Storage Targeted Dispatch, discharge (savings) Winter	CI_ADR	All	1.00	1.01	1.00	1.01	1.00	0.00	1.00
Storage Targeted Dispatch, charge (consumption) Winter	CI_ADR	All	1.00	1.01	1.00	1.01	1.00	0.00	0.00
Custom	CI_ADR	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00

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:

1 : ERS (2020). Daily Dispatch Battery Project Evaluation Report. 2019_ERS_Daily_Dispatch_Battery
2 : ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report. 2019_ERS_Cross-State_CI_DR_Evaluation
3 : ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report. 2019_ERS_Cross-State_CI_DR_Evaluation
4 : ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report. 2019_ERS_Cross-State_CI_DR_Evaluation
5 : ERS (2020). Daily Dispatch Battery Project Evaluation Report. 2019_ERS_Daily_Dispatch_Battery
6 : ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report. 2019_ERS_Cross-State_CI_DR_Evaluation

3.14. 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
Food Services - Commercial Fryer, Standard Vat	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a047
Food Services - Commercial Fryer, Large Vat	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a048
Food Services - Commercial Fryer, Standard Vat	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b046
Food Services - Commercial Fryer, Large Vat	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b047
Food Services Upstream - Commercial Fryer, Standard Vat	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b082
Food Services Upstream - Commercial Fryer, Large Vat	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b083

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator:
$\Delta kWh = \Delta kWh$
$\Delta kW = \Delta kW / Hours$
Where:
ΔkWh = gross annual kWh savings from the measure per table below
ΔkW = gross average kW savings from the measure per table below
Hours = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Fryer[1]

Equipment Type	ΔkW	ΔkWh
Standard Vat	0.50	2,976
Large Vat	0.50	2,841

Baseline Efficiency:

The baseline efficiency case for a standard sized fryer is a deep-fat fryer with a cooking energy efficiency of 75%, shortening capacity of up to 65 pounds, and idle energy rate of 1.20 kW. The baseline efficiency case for a large sized fryer is a deep-fat fryer with a cooking energy efficiency of 70%, shortening capacity of up to 100 pounds, and idle energy rate of 1.35 kW.

High Efficiency:

The high efficiency case for a standard sized fryer is a deep-fat fryer with a cooking energy efficiency of 85%, shortening capacity of up to 71 pounds, and idle energy rate of no more than 0.86 kW. For large capacity fryers (shortening capacity exceeds 70 pounds), the idle energy rate may be up to 1.1 kW.

Measure Life:

The measure life for a new commercial electric fryer is 12 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Commercial Fryer	CI_NB&MR 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}
Electric Fryer	CI_NB&MR 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
Commercial Fryer	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Commercial Fryer	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/ EIA CBECS 2012 data https://www.eia.gov/consumption/commercial data/2012/bc/cfm/b31.pnp
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.15. 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
Food Services - Commercial Electric Griddle	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a033
Food Services - Commercial Electric Griddle	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b032
Food Services Upstream - Commercial Electric Griddle	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b068

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment 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 75%, production capacity of 49.2 pounds per hour, and idle energy rate of 293 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_NB&MR 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_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:

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

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	NTG
Electric Griddle	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Electric Griddle	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators EIA CBECS 2012 data https://www.EIA.gov/consumption/commercial/data/2012/bc/cfm/b31.php
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.16. 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
Food Services - Commercial Electric Ovens, Full Size Convection	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a030
Food Services - Commercial Electric Ovens, Combination Oven	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a031
Food Services - Commercial Electric Ovens, Full Size Convection	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b029
Food Services - Commercial Electric Ovens, Combination Oven	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b030
Food Services Upstream - Commercial Electric Ovens, Full Size Convection	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b065
Food Services Upstream - Commercial Electric Ovens, Combination Oven	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b066

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment 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	0.70	2,787
Combination Oven	3.50	15,095

Baseline Efficiency:

The baseline efficiency case is a convection oven with a cooking energy efficiency of 65%, production capacity of 90 pounds per hour, and idle energy rate of 2.0 kW. The baseline efficiency case for a combination oven is a commercial combination oven with a cooking energy efficiency of 65% with a production capacity of 100 pounds per hour for oven mode and 40% steam cooking energy efficiency, with a production capacity of 150 pounds per hour for steam mode. Idle energy is assumed to be 3.7 kW for oven mode and 12.5 kW for steam mode.

High Efficiency:

The high efficiency case is a convection oven with a cooking energy efficiency of 74%, production capacity of 85 pounds per hour, and idle energy rate of 1.4 kW. The high efficiency case for a combination oven is a commercial combination oven with a cooking energy efficiency of 70% with a production capacity of 125 pounds per hour for oven mode, and 70% cooking energy efficiency with a production capacity of 200 pounds per hour for steam mode, and idle energy rate of 2.5 kW for convection mode and 6.0 kW for steam mode.

Measure Life:

The measure life for a new commercial electric oven is 12 years.[2]

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

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	Initiative	PA	FR	SO	NPSO	NTG
Food Services - Commercial Electric Ovens, Full Size Convection	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Food Services - Commercial Electric Ovens, Combination Oven	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Food Services - Commercial Electric Ovens, Full Size Convection	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services - Commercial Electric Ovens, Combination Oven	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services Upstream - Commercial Electric Ovens, Full Size Convection	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services Upstream - Commercial Electric Ovens, Combination Oven	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/ EIA CBECS 2012 data https://www.eia.gov/consumption/commercial data/2012/bc/cfm/b31.pnp
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.17. 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
Food Services - Commercial Electric Steam Cooker	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a032
Food Services - Commercial Electric Steam Cooker	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b031
Food Services Upstream - Commercial Electric Steam Cooker	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b067

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator:[1]

Measure	kWH	kW
Steam Cooker	30,156	6.89

Quantity = Number of pans. Default of 6 pans.

Baseline Efficiency:

The Baseline Efficiency case is an electric steam cooker with a cooking efficiency of 26%, pan production capacity of 70.0 pounds per hour, preheat energy of 1.5 kWh, and idle energy rate of 1.0 kW

High Efficiency:

The High Efficiency case is an ENERGY STAR® electric steam cooker with a cooking energy efficiency of 68%, pan production capacity of 88.0 pounds per hour, preheat energy of 1.5 kWh, and an idle energy rate of 0.26 kW.

Measure Life:

The measure life for a new steamer is 12 years.[2]

Other Resource Impacts:

Per unit annual water savings of 139 gallons due to the improved cooking efficiency of the high efficiency equipment[3].

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_NB&MR, 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.[4]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Commercial Electric Steam Cooker	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Commercial Electric Steam Cooker	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/ EIA CBECS

2012 data https://www.eia.gov/consumption/commercial data/2012/bc/cfm/b31.pnp
3 : FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/ EIA CBECS 2012 data https://www.eia.gov/consumption/commercial data/2012/bc/cfm/b31.pnp
4 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.18. 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
Food Services - Food Holding Cabinet, Full Size	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a049
Food Services - Food Holding Cabinet, 3/4 Size	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a050
Food Services - Food Holding Cabinet, 1/2 Size	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a051
Food Services - Food Holding Cabinet, Full Size	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b048
Food Services - Food Holding Cabinet, 3/4 Size	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b049
Food Services - Food Holding Cabinet, 1/2 Size	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b050
Food Services Upstream - Food Holding Cabinet, Full Size	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b084
Food Services Upstream - Food Holding Cabinet, 3/4 Size	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b085
Food Services Upstream - Food Holding Cabinet, 1/2 Size	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b086

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Life Cycle Kitchen 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 = Annual hours of operation. See Hours section below.

Energy Savings for Commercial Hot Food Holding Cabinets[1]

Equipment Type	kW	kWh
Full Size – 20 cu.ft.	0.50	2,737
3/4 Size – 12 cu.ft.	0.20	1,095
1/2 Size – 8 cu.ft.	0.20	1,095

Baseline Efficiency:

The baseline efficiency idle energy rate for a HFHC is 40 W for all sizes.

High Efficiency:

The high efficiency idle energy rate for HFHC is 20 W for all sizes.

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_NB&MR 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_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Food Services - Food Holding Cabinet, 3/4 Size	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Food Services - Food Holding Cabinet, 1/2 Size	CI_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Food Services - Food Holding Cabinet, Full Size	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services - Food Holding Cabinet, 3/4 Size	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services - Food Holding Cabinet, 1/2 Size	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services - Food Holding Cabinet, Full Size Food Services Upstream - Food Holding Cabinet, Full Size	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services Upstream - Food Holding Cabinet, 3/4 Size	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services Upstream - Food Holding Cabinet, 3/4 Size	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/ EIA CBECS 2012 data https://www.eia.gov/consumption/commercial data/2012/bc/cfm/b31.pnp
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 - 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
Food Services, Fryer, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a032
Food Services, Fryer, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b033
Food Services, Fryer, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b040

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator.[1]

Measure Name	MMBTU
Food Services, Fryer, Gas	78.3

Baseline Efficiency:

The baseline efficiency case is a non-Energy Star qualified fryer.

High Efficiency:

The high efficiency case is an Energy Star qualified fryer.

Measure Life:

The measure life is 12 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Fryer	CI_NB&MR 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}
Fryer	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 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
Fryer, Gas	CI_NB&MR	All	0.21	0.00	0.00	0.79
Fryer, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Fryer, Gas - Upstream	CI_EQUIP	All	0.24	0.07	0.00	0.83

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
Fryer	CI_NB&MR	All					$3.40	

Endnotes:

1 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
2 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
4 : DNV GL (2016). Commercial and Industrial New Construction Non-Energy Impacts Study DNVGL_2016_CI_NC_NEI

3.20. 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 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
Food Services, Griddle, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a031
Food Services, Griddle, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b032
Food Services, Griddle, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b039

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator.[1]

Measures	MMBTu
Griddle Gas	37.9

Baseline Efficiency:

The baseline efficiency case is a non-ENERGY STAR® qualified gas griddle.

High Efficiency:

The high efficiency case is an ENERGY STAR® qualified gas griddle.

Measure Life:

The measure life is 12 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Griddle, Gas	CI_NB&&MR 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_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 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
Food Services, Griddle, Gas	CI_NB&MR	All	0.21	0.00	0.00	0.79
Food Services, Griddle, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Food Services, Griddle, Gas - Upstream	CI_EQUIP	All	0.24	0.07	0.00	0.83

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	CI_NB&MR	All					$3.40	

Endnotes:

1 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
2 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
4 : DNV GL (2016). Commercial and Industrial New Construction Non-Energy Impacts Study DNVGL_2016_CI_NC_NEI

3.21. 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
Food Services, Ovens, Combination Oven, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a027
Food Services, Ovens, Convection Oven, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a028
Food Services, Ovens, Conveyer Oven, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a029
Food Services, Ovens, Rack Oven, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a030
Food Services, Ovens, Combination Oven, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b028
Food Services, Ovens, Convection Oven, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b029
Food Services, Ovens, Conveyer Oven, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b030
Food Services, Ovens, Rack Oven, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b031
Food Services, Ovens, Combination Oven, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b035
Food Services, Ovens, Convection Oven, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b036
Food Services, Ovens, Conveyer Oven, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b037

Measure Name	Core Initiative	BCR Measure ID
Food Services, Ovens, Rack Oven, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b038

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator:[1]

Measure Name	ΔMMBtu
Convection Oven	35.7
Combination Oven	110.3
Conveyer Oven	88.4
Rack Oven	211.3

Baseline Efficiency:

The baseline efficiency case is a standard efficiency oven. 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	30%
Combination Oven	35% (Convection Mode) 20% (Steam Mode)
Conveyer Oven	20%
Rack Oven	30%

High Efficiency:

High efficiency case is an oven that meets or exceeds the high efficiency ratings per oven type shown in table below based on ASTM F1496 (Convection Oven), ASTM F2861 (Combination Oven), and ASTM 2093 (Conveyor Oven and Rack Oven).

Measure Name	Efficiency Requirement
Convection Oven	>= 49%
Combination Oven	>= 44% (Convection) >= 38% (Steam Mode)
Conveyer Oven	>= 42%

Measure Name	Efficiency Requirement
Rack Oven	>= 50%

Measure Life:

The measure life is 12 years for all commercial ovens.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Oven	CI_NB&MR 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_NB&MR, CI_EQUIP	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Combination Oven	CI_NB&MR, CI_EQUIP	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Conveyer Oven	CI_NB&MR, CI_EQUIP	All	1.00	n/a	1.00	n/a	n/a	n/a	n/a
Rack Oven	CI_NB&MR, CIEQUIP	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.[3]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Combination Oven, Gas	CI_NB&MR	All	0.21	0.00	0.00	0.79

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Convection Oven, Gas	CI_NB&MR	All	0.21	0.00	0.00	0.79
Conveyor Oven, Gas	CI_NB&MR	All	0.21	0.00	0.00	0.79
Rack Oven, Gas	CI_NB&MR	All	0.21	0.00	0.00	0.79
Combination Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Convection Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Conveyor Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Rack Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Combination Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Convection Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Conveyor Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Rack Oven, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83

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
Oven	CI_NB&MR	All					$3.40	

Endnotes:

1 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
2 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
4 : DNV GL (2016). Commercial and Industrial New Construction Non-Energy Impacts Study DNVGL_2016_CI_NC_NEI

3.22. 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
Food Services, Steam Cooker, Gas	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a033
Food Services, Steam Cooker, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b034
Food Services, Steam Cooker, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b041

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment Savings Calculator[1]

Measure	MMBTu
Food Service, Steam Cooker, Gas	370.7

Baseline Efficiency:

The baseline efficiency case is a steamer with a 15% cooking efficiency. These performance parameters are drawn from a sample of economy grade equipment tested by the Food Service Technology Center based on ASTM F1484.

High Efficiency:

The high efficiency case is an ENERGY STAR® rated natural-gas fired steamer, with a tested heavy-load cooking efficiency of at least 38% utilizing ASTM F1484.

Measure Life:

The measure life is 12 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Steam Cooker	CI_NB&MR CI_EQUIP	All	12	n/a	n/a	12

Other Resource Impacts:

Deemed annual water savings of 105,120 gallons 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}
Steam Cooker, Gas	CI_NB&MR 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_NB&MR	All	0.21	0.00	0.00	0.79
Steam Cooker, Gas	CI_EQUIP	All	0.24	0.07	0.00	0.83
Steam Cooker, Gas - Upstream	CI_EQUIP	All	0.24	0.07	0.00	0.83

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	CI_NB&MR	All					$3.40	

Endnotes:

1 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
2 : https://caenergywise.com/calculators/ and http://www.deeresources.net/workpapers
3 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
4 : DNV GL (2016). Commercial and Industrial New Construction Non-Energy Impacts Study DNVGL_2016_CI_NC_NEI

3.23. 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
Food Services - High Temp Under Counter Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a038
Food Services - High Temp Door Type Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a039
Food Services - High Temp Single Tank Conveyer Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a040
Food Services - High Temp Multi Tank Conveyer Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a041
Food Services - High Temp Pots & Pans Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a042
Food Services - High Temp Under Counter Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b037
Food Services - High Temp Door Type Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b038
Food Services - High Temp Single Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b039
Food Services - High Temp Multi Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b040

Food Services - High Temp Pots & Pans Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b041
Food Services Upstream - High Temp Under Counter Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b073
Food Services Upstream - High Temp Door Type Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b074
Food Services Upstream - High Temp Single Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b075
Food Services Upstream - High Temp Multi Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b076
Food Services Upstream - High Temp Pots & Pans Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b077

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen 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	0.32	1,791
Door Type	0.74	4,151
Single Tank Conveyor	0.75	4,243
Multi Tank Conveyor	1.71	9,630
Pot, Pan, and Utensil	0.18	1,032

Baseline Efficiency:

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

	Idle Energy Rate (kW)	**Water Consumption (gal/rack)**
Under Counter	0.76	1.09
Door Type	0.87	1.29
Single Tank Conveyor	1.93	0.87
Multi Tank Conveyor	2.59	0.97
Pot, Pan, and Utensil	1.20	0.70

High Efficiency:

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR® V2.0 Efficiency Requirements as follows[2] :

Dishwasher Type	**Idle Energy Rate (kW)**	**Water Consumption (gal/rack)**
Under Counter	0.50	0.86
Door Type	0.70	0.89
Single Tank Conveyor	1.50	0.70
Multi Tank Conveyor	2.25	0.54
Pot, Pan, and Utensil	1.20	0.58

Measure Life:

The measure life for a new high temperature dishwasher is given by type below:[3]

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 water savings associated with this measure[4] .

Dishwasher Type	Annual water savings (gal/unit)
Under Counter	5,399
Door Type	35,056
Single Tank Conveyor	21,284
Multi Tank Conveyor	80,754
Pot, Pan, and Utensil	10,517

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_NB&MR 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_NB&MR	All	39.7%	2.8%	3.4%	66.5%
Food Services - High Temp Dishwasher	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%
Food Services Upstream - High Temp Dishwasher	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers

2

https://www.energystar.gov/sites/default/files/specs/private/ENERGY%20STAR_CD_V2.0_Final%20Sp

ecification.pdf
3 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
4 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.24. 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
Food Services - Commercial Ice Machine, Ice Making Head	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a043
Food Services - Commercial Ice Machine, Self Contained Unit	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a044
Food Services - Commercial Ice Machine, Remote Condensing Unit (Batch)	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a045
Food Services - Commercial Ice Machine, Remote Condensing Unit (Continuous)	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a046
Food Services - Commercial Ice Machine, Ice Making Head	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b042
Food Services - Commercial Ice Machine, Self Contained Unit	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b043
Food Services - Commercial Ice Machine, Remote Condensing Unit (Batch)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b044
Food Services - Commercial Ice Machine, Remote Condensing Unit (Continuous)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b045
Food Services Upstream - Commercial Ice Machine, Ice Making Head	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b078

Measure Name	Core Initiative	BCR Measure ID
Food Services Upstream - Commercial Ice Machine, Self Contained Unit	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b079
Food Services Upstream - Commercial Ice Machine, Remote Condensing Unit (Batch)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b080
Food Services Upstream - Commercial Ice Machine, Remote Condensing Unit (Continuous)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b081

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen 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 Commercial Ice Machine:[1]

Equipment Type	kW	kWh
Ice Making Head	0.30	1,117
Self Contained Unit	0.30	805
Remote Condensing Unit (Batch)	0.30	2,601
Remote Condensing Unit (Continuous)	0.30	3,641

Baseline Efficiency:

The baseline efficiency case is a non-ENERGY STAR® commercial ice machine.

High Efficiency:

The high efficiency case is a commercial ice machine meeting the ENERGY STAR® 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_NB&MR CI_EQUIP	All	8	n/a	n/a	8

Other Resource Impacts:

There are water savings associated with this measure[4] :

Dishwasher Type	Annual water savings (gal/unit)
Ice Making Head	3,322
Self Contained Unit	3,526
Remote Condensing Unit (Batch)	2,631
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_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.[5]

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	NTG
Ice Making Machine	CI_NB&MR	All	39.7%	2.8%	3.4%	66.4%
Ice Making Machine	CI_EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : https://www.energystar.gov/sites/default/files/Final%20V3.0%20ACIM%20Specification%205-17-17_1_0.pdf
3 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
4 : https://www.energystar.gov/sites/default/files/Final%20V3.0%20ACIM%20Specification%205-17-17_1_0.pdf
5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.25. 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
Food Services - Low Temp Under Counter Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a034
Food Services - Low Temp Door Type Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a035
Food Services - Low Temp Single Tank Conveyer Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a036
Food Services - Low Temp Multi Tank Conveyer Dishwasher	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a037
Food Services - Low Temp Under Counter Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b033
Food Services - Low Temp Door Type Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b034
Food Services - Low Temp Single Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b035
Food Services - Low Temp Multi Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b036
Food Services Upstream - Low Temp Under Counter Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b069
Food Services Upstream - Low Temp Door Type Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b070

Measure Name	Core Initiative	BCR Measure ID
Food Services Upstream - Low Temp Single Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b071
Food Services Upstream - Low Temp Multi Tank Conveyer Dishwasher	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b072

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on the FSTC Commercial Kitchen Equipment 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	0.39	2,178
Door Type	2.46	13,851
Single Tank Conveyor	2.07	11,685
Multi Tank Conveyor	2.86	16,131

Baseline Efficiency:

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
Under Counter	0.50	1.73
Door Type	0.60	2.10
Single Tank Conveyor	1.50	1.31
Multi Tank Conveyor	2.00	1.04

High Efficiency:

The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR efficiency requirements as follows[2] :

Dishwasher Type	Max Idle Energy Rate (kW)	Max Water Consumption (gal/rack)
Under Counter	0.50	1.19
Door Type	0.60	1.18
Single Tank Conveyor	1.50	0.79
Multi Tank Conveyor	2.00	0.54

Measure Life:

The measure life for a new low temperature dishwasher is given by type below:[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Under Counter	CI_NB&MR CI_EQUIP	All	10	n/a	n/a	10
Door Type	CI_NB&MR CI_EQUIP	All	15	n/a	n/a	15
Single or Multi Tank Conveyor	CI_NB&MR CI_EQUIP	All	20	n/a	n/a	20

Other Resource Impacts:

There are water savings associated with this measure.[4]

Dishwasher Type	Annual water savings (Gal/Unit)
Under Counter	12,677
Door Type	80,629
Single Tank Conveyor	65,104
Multi Tank Conveyor	93,900

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_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[5]

Measure	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Food Services - Low Temp Dishwasher	CI_NB&MF	All	0.40	0.03	0.03	0.67
Food Services - Low Temp Dishwasher	CI_EQUIP	All	0.23	0.09	0.00	0.86
Food Services Upstream - Low Temp Dishwasher	CI_EQUIP	All	0.23	0.09	0.00	0.86

Non-Energy Impacts:

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

Endnotes:

1 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
2 : https://www.energystar.gov/sites/default/files/specs/private/ENERGY%20STAR_CD_V2.0_Final%20Specification.pdf
3 : https://caenergywise.com/calculators/ http://www.deeresources.net/workpapers
4 : https://caenergywise.com/calculators/natural-gas-combination-ovens/#calc http://www.deeresources.net/workpapers
5 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.26. 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
Food Services Upstream - Commercial Refrigerator, Glass Door	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b089
Food Services Upstream - Commercial Refrigerator, Solid Door	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b090
Food Services Upstream - Commercial Freezer, Glass Door	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b091
Food Services Upstream - Commercial Freezer, Solid Door	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b092

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 (v4).[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

Description	Annual Gross kWh Savings	kW Savings
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:

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.[2]

Measure	Core Initiative	PA	FR	SO_p	SO_{NP}	NTG
Food Services Upstream - Commercial Refrigerator/Freezer (All)	CI_EQUIP	All	0.225	0.085	0.000	0.860

Non-Energy Impacts:

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

Endnotes:

1 :
https://www.energystar.gov/sites/default/files/asset/document/Commercial%20Refrigerators%20and%20Freezers%20V4%20Spec%20Final%20Version_0.pdf
2 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.27. 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	C&I Existing Building Retrofit (CI_RETRO)	G19C2a015
Boiler Reset Control (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a049

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	0.22	0.03	0.00	0.80

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					$1.35	

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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
4 : KEMA (2012). Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy impacts Study TETRATECH_2012_MA_CI_NEI_REPORT

3.28. 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
HVAC Upstream - Circulator Pump	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b057

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 2018.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
HVAC Upstream - Circulator Pump - 2019	CI_EQUIP	All	0.45	0.00	0.00	0.55
HVAC Upstream - Circulator Pump - 2020	CI_EQUIP	All	0.46	0.00	0.00	0.54
HVAC Upstream - Circulator Pump - 2021	CI_EQUIP	All	0.47	0.00	0.00	0.53

Non-Energy Impacts:

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

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

3.29. 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	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a026
Heating System, Combo Condensing Boiler/Water Heater, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b018

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 2018 C&I NTG evaluation.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Combo Condensing Boiler/Water Heater	CI_NB&MR	All	0.21	0.00	0.10	0.79
Combo Condensing Boiler/Water Heater	CI_Equip	All	0.24	0.07	0.00	0.83

Non-Energy Impacts:

Non-energy impact factors come from the 2012 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					$-0.084	

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. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
4 : KEMA (2012). Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy impacts Study.

3.30. 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)	G19C2b042

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:

2018 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	0.24	0.07	0.00	0.83

Non-Energy Impacts:

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

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.

3.31. 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, Gas	C&I Existing Building Retrofit (CI_RETRO)	G19C2a017
Wi-Fi Thermostat, Gas (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a038
Wi-Fi Thermostat, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a068
Wi-Fi Thermostat, AC Only (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a085
Wi-Fi Thermostat, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a086
Wi-Fi Thermostat, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a087

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			3.11
Wi-Fi Thermostat, Gas (Turnkey)			3.11
Wi-Fi Thermostat, Gas (Residential End Use)	18	0.03	3.11

Measure Name	ΔkWh	ΔkW[2]	Δ MMBtu
Wi-Fi Thermostat, AC Only (Residential End Use)	64	0.10	
Wi-Fi Thermostat, Oil (Residential End Use)	18	0.03	3.11
Wi-Fi Thermostat, Other (Residential End Use)	18	0.03	3.11

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	0.35	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	n/a	n/a
Wi-Fi Thermostat, Gas (High Rise)	CI_RETRO	All	1.00	1.00	1.00	1.00	1.00	0.35	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 demand allocation methodology described the Demand Impact Model.[4]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Wi-Fi Thermostat, Gas	CI_RETRO	All	0.22	0.03	0.00	0.80
Wi-Fi Thermostat, Gas (Turnkey)	CI_RETRO	All	0.22	0.03	0.00	0.80
Wi-Fi Thermostat (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

Non-Energy Impacts:

C&I values from 2012 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, Gas	CI_RETRO	All					$1.35	
Wi-Fi Thermostat, Gas (Turnkey)	CI_RETRO	All					$1.35	
Wi-Fi Thermostat (Residential End Use)	CI_RETRO	All	$14.35					

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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation
6 : TETRATECH_2012_MA_CI_NEI_REPORT

3.32. 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 Buildings & Major Renovations (CI_NB&MR)	G19C1a017
Heating System, Condensing Boiler, Gas <= 300 mbh (.90 TE)	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a018
Heating System, Condensing Boiler, Gas 301-499 mbh (.90 TE)	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a019
Heating System, Condensing Boiler, Gas 500-999 mbh (.90 TE)	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a020
Heating System, Condensing Boiler, Gas 1000-1700 mbh (.90 TE)	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a021
Heating System, Condensing Boiler, Gas 1701+ mbh (.90 TE)	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a022
Heating System, Condensing Boiler, Gas <= 300 mbh (.95 TE)	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b011
Heating System, Condensing Boiler, Gas <= 300 mbh (.90 TE)	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b012
Heating System, Condensing Boiler, Gas 301-499 mbh (.90 TE)	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b013
Heating System, Condensing Boiler, Gas 500-999 mbh (.90 TE)	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b014
Heating System, Condensing Boiler, Gas 1000-1700 mbh (.90 TE)	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b015

Measure Name	Core Initiative	BCR Measure ID
Heating System, Condensing Boiler, Gas 1701+ mbh (.90 TE)	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b016

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	ΔMMBtu
<= 300 mbh (0.95 TE)	17.7
<= 300 mbh (0.90 TE)	14.7
301-499 mbh (0.90 TE)	28.0
500-999 mbh (0.90 TE)	51.4
1000-1700 mbh (0.90 TE)	94.5
1701+ mbh (0.90 TE)	165.3

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 25 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Condensing Boilers	CI_NB&MR CI_EQUIP	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}
Condensing Boilers	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. 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_NB&MR	All	0.21	0.00	0.001	0.79
Condensing Boilers	CI_EQUIP	All	0.24	0.07	0.00	0.83

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					$-0.084	

Endnotes:

1 : DNV GL, 2016, Prescriptive Gas Boiler Baseline Change Memo
DNVGL_2016_Prescriptive_Gas_Boiler_Baseline_Change_Memo
2 : DNVGL,NMR Group, 2017, Gas Boiler Market Characterization
DNVGL_2017_Gas_Boiler_Market_Characterization
2 : ASHRAE Applications Handbook (2003); Page 36.3
4 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
5 : KEMA (2012). Commercial and Industrial Non-Energy impacts Study.
TETRATECH_2012_MA_CI_NEI_REPORT

3.33. 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)	G19C1a023
Condensing Unit Heater, Gas <= 300 mbh	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b019

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	ΔMMBtu
Condensing Unit Heater (<= 300 mbh)	40.9

Baseline Efficiency:

The baseline efficiency case is a standard efficiency gas fired unit heater with minimum combustion efficiency of 80%, interrupted or intermittent ignition device (IID), and either power venting or an automatic flue damper[2]. As a note, the baseline efficiency referenced applies to 2016. Baseline requirements for 2017 and on have not been finalized.

High Efficiency:

The high efficiency case is a condensing gas unit heater with 90% AFUE or greater.

Measure Life:

The measure life is 18 years.[3]

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. 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 deemed from study results.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Condensing Boilers	CI_NB&MR	All	0.21	0.00	0.001	0.79
Condensing Boilers	CI_EQUIP	All	0.24	0.07	0.00	0.83

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	All					$0.053	

Endnotes:

1 : NYSERDA Deemed Savings Database (Rev 11); Measure Name: A.UNIT-HEATER-COND.
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
4 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
5 : KEMA (2012). Commercial and Industrial Non-Energy impacts Study. TETRATECH_2012_MA_CI_NEI_REPORT

3.34. 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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Cooler Night Covers	CI_RETRO	ES, CLC	1.00	0.91	n/a	0.92	0.92	0.00	0.00
Refrigeration - Cooler Night Covers	CI_RETRO	NGRID, Unitil	1.00	1.00	n/a	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:

- National Grid, Unitil: RRs set to 100% based on no evaluations.
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors:

Coincidence factors are set to zero since demand savings typically occur during off-peak hours.

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.[4]

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.[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
Refrigeration - Cooler Night Covers	CI_RETRO	All			$0.047			

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

4 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

5 : KEMA (2012). Commercial and Industrial Non-Energy Impacts Study. TETRATECH_2012_MA_CI_NEI_REPORT

3.35. HVAC - Demand Control Ventilation

Measure Code	COM-HVAC-DCV
Market	Commercial
Program Type	Retrofit
Category	Heating Ventilation and Air Conditioning

Measure Description:

The measure controls the quantity of outside air to an air handling system based on detected space CO2 levels. The installed systems monitor the CO2 in the spaces or return air and reduce the outside air use when possible to save energy while meeting indoor air quality standards.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
HVAC Upstream - Demand Control Ventilation (DCV)	CI_EQUIP	E19C2b056

Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings for implementation of demand control ventilation are custom calculated using the PA's DCV savings calculation tools. These tools are used to calculate energy and demand savings based on site-specific project details including hours of operation, HVAC system efficiency and total air flow, and enthalpy and temperature set points.[1] Alternatively, the energy and demand savings may be calculated using the following algorithms and inputs:

kWh = kBtuh * (1 Ton/12 kBtu/h) * SAVEkWh
kW = kBtuh * (1 Ton/12 kBtu/h) * SAVEkW

Where:
kBtu/h = Capacity of the cooling equipment in kBtu per hour
SAVEkWh = Average annual kWh reduction per ton of cooling capacity: 170 kWh/ton[2]
SAVEkW = Average kW reduction per ton of cooling capacity: 0.15 kW/ton[3]

Baseline Efficiency:

The baseline efficiency case assumes the relevant HVAC equipment has no ventilation control.

High Efficiency:

The high efficiency case is the installation of an outside air intake control based on CO2 sensors.

Measure Life:

The measure life is 10 years.[4]

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}	CF_{SP}	CF_{WP}
DCV	CI_EQUIP	All	1.00	1.01	n/a	1.09	1.57	0.82	0.05	n/a	n/a

In-Service Rates:

All installations have 100% in-service rates.

Realization Rates:

RRs are from an impact evaluation 2006 HVAC installations.[5]

Coincidence Factors:

CFs based on standard assumptions.[6]

Impact Factors for Calculating Net Savings:

Statewide net impact factors are based on an Upstream HVAC Net-to-Gross study in Massachusetts in 2018.[7]

Measure	Initiative	PA	FR	SO_P	SO_{NP}	NTG
HVAC Upstream - DEMAND CONTROL VENTILATION (DCV)- 2019	CI_EQUIP	All	0.45	0.00	0.00	0.55
HVAC Upstream - DEMAND CONTROL VENTILATION (DCV)- 2020	CI_EQUIP	All	0.46	0.00	0.00	0.54
HVAC Upstream - DEMAND CONTROL VENTILATION (DCV)- 2021	CI_EQUIP	All	0.47	0.00	0.00	0.53

Non-Energy Impacts:

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

Endnotes:

1 : Detailed descriptions of the DCV Savings Calculation Tools are included in the TRM Library under the “C&I Spreadsheet Tools” folder.
2 : Keena, Kevin (2008). Analysis of CO2 Control Energy Savings on Unitary HVAC Units. Prepared for National Grid. Kenna_2008_Analysis_of_CO2_Ctrl_Energy_Savings_on_Unitary_HVAC
3 : Keena, Kevin (2008). Analysis of CO2 Control Energy Savings on Unitary HVAC Units. Prepared for National Grid. Kenna_2008_Analysis_of_CO2_Ctrl_Energy_Savings_on_Unitary_HVAC
4 : Energy & Resource Solutions (2005). Measure Life Study. Measure life is assumed to be the same as Enthalpy Economizer. ERS_2005_Measure_Life_Study
5 : RLW Analytics (2008). Business & Construction Solutions (BS/CS) Programs Measurement &

Verification 2006 Final Report. Prepared for NSTAR; Table 17.
RLW_2008_Business_and_Construction_Solutions_Programs_Measurement_and_Verification_2006_Final_Report
6 : MA Common Assumption
7 : 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

3.36. 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
HVAC Upstream - Dual Enthalpy Economizer Controls (DEEC)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b054

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 - 2019	CI_EQUIP	All	0.45	0.00	0.00	0.55
HVAC Upstream - Dual Enthalpy Economizer ControlsHVAC Upstream - Dual Enthalpy Economizer ControlsHVAC Upstream - Dual Enthalpy Economizer ControlsHVAC Upstream - Dual Enthalpy Economizer ControlsHVAC Upstream - Dual Enthalpy Economizer Controls - 2020	CI_EQUIP	All	0.46	0.00	0.00	0.54
HVAC Upstream - Dual Enthalpy Economizer Controls - 2021	CI_EQUIP	All	0.47	0.00	0.00	0.53

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:

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

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

3.37. 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, Gas	C&I Existing Building Retrofit (CI_RETRO)	G19C2a019
Duct Insulation, Gas (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a041

Algorithms for Calculating Primary Energy Impact:

Deemed average annual MMBtu savings of 0.13 are assumed per unit.[1]

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]

PA	Measure Name	Core Initiative	EUL	OYF	RUL	AML
All	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:

PA	Measure Name	Core Initiative	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
All	Duct Insulation	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 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:

Impact factors are from the 2018 C&I NTG evaluation.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Duct Insulation	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 : 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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.38. HVAC - Duct Insulation - C&I 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)	E19C2a065
Duct Insulation, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a059

Algorithms for Calculating Primary Energy Impact:

Deemed average annual MMBtu savings of 0.13 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	0.35	0.00

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.[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	0.21	0.13	0.17	1.09
Duct Insulation, Elec (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

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 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

3.39. 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	Existing Building Retrofit (CI_RETRO)	G19C2a020
Duct Sealing, Gas (Turnkey)	Existing Building Retrofit (CI_RETRO)	G19C2a040

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: 0.13[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	0.804

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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.40. HVAC - Duct Sealing - C&I 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)	E19C2a064
Duct Sealing, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a058

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	0.35	0.00

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 demand allocation methodology described the Demand Impact Model.[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	0.21	0.13	0.17	1.09

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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
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

3.41. 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)	E19C2a006
EMS (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a045

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 2018 C&I NTG evaluation.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Energy Management System	CI_RETRO	All	13.5%	5.3%	1.8%	93.5%

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			$0.097			

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

3.42. 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%	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a014
Heating System, Furnace, Gas 97%	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a016
Heating System, Furnace, Gas 95%	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b008
Heating System, Furnace, Gas 97%	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b010

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	ΔMMBtu	ΔkWh[2]	ΔkW
Furnace, 95%	5.7	168	0.124
Furnace, 97%	6.7	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_NB&&MR, 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_NB&MR 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_NB&MR	All	20.8%	0.0%	0.1%	79.3%
Furnaces	CI_EQUIP	All	23.7%	7.0%	0.0%	83.3%

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_NB&MR	All					$0.053	

Endnotes:

1 : DNV-GL (2015). Recalculation of Prescriptive Program Gas Furnace Savings Using New Baseline. DNVGL_2015_Prescriptive_Gas_Furnace_Savings_Baseline_Change_Memo_3-5-15
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

3.43. 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)	E19C2a108

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:

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

Endnotes:

1 : Navigant (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

3.44. 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
HVAC Upstream - Heat Pump Systems	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b052
HVAC Upstream - DMSHP Systems	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b053
HVAC Upstream - Water Source Heat Pump Systems	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b064
HVAC Upstream - VRF	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b087

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

PA	$EFLH_{cool}$	$Hours_{cool}$	Cap_{adj}	$EFLH_{heat}$
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	15.0 SEER	9.0 HSPF
		2			12.0 EER	16.0 SEER	9.0 HSPF
		3			12.0 EER	17.0 SEER	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	13.1 IEER	3.4 COP
		2			12.0 EER	14.5 IEER	3.4 COP
		3			12.0 EER	18.0 IEER	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	13.0 IEER	3.2 COP
		2			11.5 EER	14.0 IEER	3.2 COP
		3			11.5 EER	17.5 IEER	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	12.0 IEER	3.2 COP
		2			10.1 EER	13.0 IEER	3.2 COP
		3			10.1 EER	14.0 IEER	3.2 COP
Air-Cooled	AC or HP	1	≥ 760 kBtuh (≥ 63.3 Tons)	Split System and Single Package	9.7 EER	13.0 IEER	3.2 COP
		2			9.7 EER	14.0 IEER	3.2 COP
		3			9.7 EER	16.0 IEER	3.2 COP

Equipment Type	Unit Type	Tier	Size Category	Sub Category	Full Load Cooling Efficiency	Seasonal/ Part Load Cooling Efficiency	Heating Efficiency
Water-Cooled	Water Source HP	1	Any Size	Split System and Single Package	14.0 EER	-	4.6 COP
		2			15.0 EER	-	4.6 COP
		3			16.0 EER	-	4.6 COP
Water-Cooled	Ground Source Closed Loop HP	1	Any Size	Split System and Single Package	15.0 EER	-	3.5 COP
Water-Cooled	Ground Source Open Loop HP	1	Any Size	Split System and Single Package	19.0 EER	-	4.0 COP
Water-Cooled or Evaporatively-Cooled	AC	1	< 65 kBtuh (< 5.4 Tons)	Split System and Single Package	13.5 EER	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	15.5 IEER	-
Water-Cooled or Evaporatively-Cooled	AC	1	≥ 240 kBtuh (≥ 20 Tons)	Split System and Single Package	12.5 EER	14.5 IEER	-
Air-Cooled	AC or HP (Ductless Mini/Multi Split)	1	< 65 kBtuh (<5.4 Tons)	Ductless Mini and Multi Splits	12.0 EER	20 SEER	9.0 HSPF
		2			12.0 EER	23 SEER	11.5 HSPF
Air-Cooled	HP (VRF)	1	≥ 65 kBtuh (≥5.4 Tons)	VRF	11.0 EER	18 IEER	3.4 COP
	HP (VRF)	1		VRF	12.0 EER	20 IEER	4.3 COP

Equipment Type	Unit Type	Tier	Size Category	Sub Category	Full Load Cooling Efficiency	Seasonal/ Part Load Cooling Efficiency	Heating Efficiency
Water-Cooled			≥ 65 kBtuh (≥5.4 Tons)				

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.[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

3.45. 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)	E19C1a011
High Efficiency Chiller -- FL	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a012
High Efficiency Chiller -- IPLV	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b010
High Efficiency Chiller -- FL	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b011

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 B	
			Full Load	IPLV	Full Load	IPLV
Air-cooled chillers	<150	EER (Btu/W)	10.100	13.700	9.700	15.800
Air-cooled chillers	≥150	EER (Btu/W)	10.100	14.000	9.700	16.100
Water cooled, electrically operated positive displacement	<75	kW/ton	0.750	0.600	0.780	0.500
Water cooled, electrically operated positive displacement	≥75 and <150	kW/ton	0.720	0.560	0.750	0.490
Water cooled, electrically operated positive displacement	≥150 and <300	kW/ton	0.660	0.540	0.680	0.440
Water cooled, electrically operated positive displacement	≥300 and <600	kW/ton	0.610	0.520	0.625	0.410
Water cooled, electrically operated positive displacement	≥600	kW/ton	0.560	0.500	0.585	0.380
Water cooled, electrically operated centrifugal	<150	kW/ton	0.610	0.550	0.695	0.440
Water cooled, electrically operated centrifugal	≥150 and <300	kW/ton	0.610	0.550	0.635	0.400

Water cooled, electrically operated centrifugal	≥300 and <400	kW/ton	0.560	0.520	0.595	0.390
Water cooled, electrically operated centrifugal	≥400 and <600	kW/ton	0.560	0.500	0.585	0.380
Water cooled, electrically operated centrifugal	≥600	kW/ton	0.560	0.500	0.585	0.380

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 fulfil 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 Prescriptive net-to-gross results.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
High Efficiency Chiller - IPLV	CI_NB&MR CI EQUIP	All	39.7%	2.8%	3.4%	66.4%
High Efficiency Chiller - FL	CI_NB&MR CI EQUIP	All	22.5%	8.5%	0.0%	86.0%

Non-Energy Impacts:

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

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

3.46. 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)	E19C2a029

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	15	1.00	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}
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	13.5%	5.3%	1.8%	93.5%

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			$0.097			

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

3.47. 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)	G19C1a024
Infrared Heaters, Gas	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b020

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 2018 C&I NTG study.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Infrared Heaters	CI_NB&MR	All	0.208	0.00	0.001	0.79
Infrared Heaters	CI_EQUIP	All	0.237	0.07	0.00	0.83

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
Infrared Heaters	CI_NB&MR	All					$0.053	

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. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.48. 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, 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, Gas, <= 1.5”	0.21
Pipe Wrap Steam, Gas, 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, Gas	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, Gas	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:

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	0.22	0.03	0.00	0.80

Non-Energy Impacts:

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

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
3 : NMR Group, Inc. (2018). Massachusetts Sponsor's Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.49. HVAC - Pipe Wrap (Heating) - C&I 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)	G19C2a061

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	0.21	0.13	0.17	1.09

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

3.50. 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)	G19C2a066

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results[1]

Measure Name	ΔMMBtu
Programmable Thermostat, Gas (Residential End Use)	2.3

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 15 years.[2] The measure persistence was estimated to be 69%[3] so the effective measure life is 10 years (15 years * 69%).

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Programmable Thermostat (Residential End Use)	CI_RETRO	All	15	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}
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 demand allocation methodology described the Demand Impact Model.[4]

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
Programmable Thermostat (Single Family)	RES_CD	All	0.11	0.00	0.00	0.89
Programmable Thermostat (Attached Low Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Programmable Thermostat (High Rise)	RES_CD	All	0.21	0.13	0.17	1.09
Programmable Thermostat	RES_RETAIL	All	0.58	0.00	0.00	0.42

Non-Energy Impacts:

NEI values are rolled up, component values can be found in Appendix B.[7] 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 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. 2018_Navigant_HES_Impact_Evaluation
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 : The Cadmus Group, Inc. (2012). Massachusetts 2011 Residential Retrofit Multifamily Program Analysis. CADMUS_2012_Multifamily_Impacts_Analysis_Report
4 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
5 : NMR Group, Inc. (2011). Estimated Net-To-Gross (NTG) Factors for the Massachusetts Program Administrators (PAs) 2010 Residential New Construction Programs, Residential High Efficiency Heating Equipment (HEHE) and Multi-Family Gas Programs, and Commercial and Industrial Gas Programs.
TetraTech_2011_Estimated_NTG_2010_Gas_Programs
6 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

3.51. 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 Thermostats (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a047
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:

$kWh = (SQFT)(SAVE_{kWh})$
$kW = (SQFT)(SAVE_{kW})$
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

Measure Name	SAVEkWh (kWh/SqFt)[1]	SAVEkW (kW/SqFt)
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

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 8 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Programmable Thermostat	CI_RETRO	All	8	n/a	n/a	8

Other Resource 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 2018 C&I NTG study.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Programmable Thermostats	CI_RETRO	All	0.14	0.05	0.02	0.94

Non-Energy Impacts:

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

Endnotes:

1 : All deemed savings values based on Massachusetts common assumptions.
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.
4 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.52. HVAC - Programmable Thermostat, Gas

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, 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 Thermostats, Gas	3.5

Baseline Efficiency:

The baseline efficiency case is an HVAC system using natural gas to provide space heating without a programmable thermostat.

High Efficiency:

The high efficiency case is an HVAC system using natural gas to provide space heating with a 7-day programmable thermostat installed.

Measure Life:

The measure life is 15 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Programmable Thermostat, Gas	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, Gas	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 100% energy realization rate. The summer and winter peak realization rate are not applicable for this measure since there are no electric savings claimed.

Coincidence Factors:

All PAs CFs set to zero since this is a gas measure.

Impact Factors for Calculating Net Savings:

Values from 2018 C&I NTG study.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Programmable Thermostats, Gas	CI_RETRO	All	0.22	0.03	0.00	0.80

Non-Energy Impacts:

Values from 2012 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					$1.35	

Endnotes:

1 : Navigant Consulting (2018). Home Energy Services (HES) Impact Evaluation. 2018_Navigant_HES_Impact_Evaluation
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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

4 : KEMA (2012). Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy impacts Stud TETRATECH_2012_MA_CI_NEI_REPORT

3.53. 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
HVAC Upstream - Unitary Air Conditioners	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b051

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 2015 energy code for 2019. For 2020+, baseline assumptions have not been finalized but will likely be in accordance with IECC 2018 requirements.

A/C Baseline Efficiency Requirements

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	15.0 SEER	9.0 HSPF
		2			12.0 EER	16.0 SEER	9.0 HSPF
		3			12.0 EER	17.0 SEER	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	13.1 IEER	3.4 COP
		2			12.0 EER	14.5 IEER	3.4 COP
		3			12.0 EER	18.0 IEER	3.4 COP
Air-Cooled	AC or HP	1	≥ 135 kBtuh and < 240 kBtuh (≥ 11.3 Tons	Split System and Single Package	11.5 EER	13.0 IEER	3.2 COP
		2			11.5 EER	14.0 IEER	3.2 COP
		3			11.5 EER	17.5 IEER	3.2 COP

Equipment Type	Unit Type	Tier	Size Category	Sub Category	Full Load Cooling Efficiency	Seasonal/ Part Load Cooling Efficiency	Heating Efficiency
			and < 20 Tons)				
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	12.0 IEER	3.2 COP
		2			10.1 EER	13.0 IEER	3.2 COP
		3			10.1 EER	14.0 IEER	3.2 COP
Air-Cooled	AC or HP	1	≥ 760 kBtuh (≥ 63.3 Tons)	Split System and Single Package	9.7 EER	13.0 IEER	3.2 COP
		2			9.7 EER	14.0 IEER	3.2 COP
		3			9.7 EER	16.0 IEER	3.2 COP
Water-Cooled	Water Source HP	1	Any Size	Split System and Single Package	14.0 EER	-	4.6 COP
		2			15.0 EER	-	4.6 COP
		3			16.0 EER	-	4.6 COP
Water-Cooled	Ground Source Closed Loop HP	1	Any Size	Split System and Single Package	15.0 EER	-	3.5 COP
Water-Cooled	Ground Source Open Loop HP	1	Any Size	Split System and Single Package	19.0 EER	-	4.0 COP
Water-Cooled or Evaporatively-Cooled	AC	1	< 65 kBtuh (< 5.4 Tons)	Split System and Single Package	13.5 EER	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	15.5 IEER	-
Water-Cooled or Evaporatively-Cooled	AC	1	≥ 240 kBtuh (≥ 20 Tons)	Split System and Single Package	12.5 EER	14.5 IEER	-

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 (Ductless Mini/Multi Split)	1	< 65 kBtuh (<5.4 Tons)	Ductless Mini and Multi Splits	12.0 EER	20 SEER	9.0 HSPF
		2			12.0 EER	23 SEER	11.5 HSPF
Air-Cooled	HP (VRF)	1	≥ 65 kBtuh (≥5.4 Tons)	VRF	11.0 EER	18 IEER	3.4 COP
Water-Cooled	HP (VRF)	1	≥ 65 kBtuh (≥5.4 Tons)	VRF	12.0 EER	20 IEER	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 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 2018 in Massachusetts.[5]

Measure	Initiative	PA	FR	SO_P	SO_{NP}	NTG
HVAC - Upstream - Unitary Air Conditioner	CI_EQUIP	All	0.45	0.00	0.00	0.55
HVAC - Upstream - Unitary Air Conditioner	CI_EQUIP	All	0.46	0.00	0.00	0.54
HVAC - Upstream - Unitary Air Conditioner	CI_EQUIP	All	0.47	0.00	0.00	0.53

Non-Energy Impacts:

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

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

3.54. 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)	G19C2b025

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 2018 C&I Upstream HVAC NTG study. [4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	2019 NTG	2020 NTG	2021 NTG
Condensing Water Heater, Gas 0.94 - Upstream	CI_Equip	All	N/A	N/A	N/A	0.31	0.30	0.29

Non-Energy Impacts:

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

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

3.55. 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, Gas	C&I Existing Building Retrofit (CI_RETRO)	G19C2a021
Faucet Aerator, Gas (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a042

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure Name	ΔMMBtu
Faucet Aerator, Gas	1.7

Baseline Efficiency:

The baseline efficiency case is a 2.2 GPM faucet.[2]

High Efficiency:

The high efficiency case is a faucet with 1.5 GPM or less aerator installed.[3]

Measure Life:

The measure life is 10 years.[4]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Faucet Aerator, Gas	CI_RETRO	All	10	n/a	n/a	10

Other Resource Impacts:

There are deemed water savings of 5,460 gallons/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, Gas	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 evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Faucet Aerator, Gas	CI_RETRO	All	0.221	0.025	0.00	0.804

Non-Energy Impacts:

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

Endnotes:

1 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-16
GDS_2009_Natural_Gas_Energy_Efficiency_Potential_in_MA
2 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-16
GDS_2009_Natural_Gas_Energy_Efficiency_Potential_in_MA
3 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-16
GDS_2009_Natural_Gas_Energy_Efficiency_Potential_in_MA
4 : GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-16
GDS_2009_Natural_Gas_Energy_Efficiency_Potential_in_MA
5 : Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads.
6 : NMR (2018). Massachusetts Sponsor's Commercial and Industrial Free-ridership and Spillover Study.
2018_NMR_CI FR-SO Report

3.56. Hot Water - Faucet Aerator - C&I 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)	E19C2a066
Faucet Aerator, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a067
Faucet Aerator, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a068
Faucet Aerator, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a069
Faucet Aerator, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a062

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1] Demand savings are based on the demand model.[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	0.81

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% for deemed measures.

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 for attached low rise and high rise are based on evaluation results.[6]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Faucet Aerator (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

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 (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 : 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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
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

3.57. 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)	G19C2b023

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 deemed study.[4]

Measure Name	Core Initiative	PA	2019 NTG	2020 NTG	2021 NTG
Indirect Water Heater, Gas - Upstream	CI_EQUIP	All	31%	30%	29%

Non-Energy Impacts:

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

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

3.58. 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, Gas	C&I Existing Building Retrofit (CI_RETRO)	G19C2a022
Low-Flow Showerhead, Gas (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a043
Low-Flow Showerhead, Electric	C&I Existing Building Retrofit (CI_RETRO)	E19C2a042

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed.[1]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
Low-Flow Showerhead, Electric	513	0.09	
Low-Flow Showerhead, Gas			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 10 years.[2]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead	CI_RETRO	All	10	n/a	n/a	10

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	0.52	1.00
Low-Flow Showerhead, Gas	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 values are based on evaluation results.[4]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Low-Flow Showerhead, Electric	CI_RETRO	All	0.14	0.05	0.02	0.94
Low-Flow Showerhead, 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 : 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%.

2 : 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
3 : Federal Energy Management Program (2011). Energy Cost Calculator for Faucets and Showerheads.
4 : NMR (2018). Massachusetts Sponsor's Commercial and Industrial Free-ridership and Spillover Study.
2018_NMR_CI FR-SO Report

3.59. Hot Water - Low-Flow Showerhead - C&I 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)	E19C2a070
Low-Flow Showerhead, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a071
Low-Flow Showerhead, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a072
Low-Flow Showerhead, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a073
Low-Flow Showerhead, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a063

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 7 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead	CI_RETRO	All	7	n/a	n/a	7

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	0.81
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	0.21	0.13	0.17	1.09

Non-Energy Impacts:

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

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 : MA Common Assumptions
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 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

3.60. Hot Water - Low-Flow Showerhead with Thermostatic Valve - C&I 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 (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a074
Low-Flow Showerhead with TSV, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a075
Low-Flow Showerhead with TSV, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a076
Low-Flow Showerhead with TSV, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a064

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on engineering analysis.[1] kW savings are calculated using the demand impact model.[2]

Measure Name	ΔkWh	ΔkW	ΔMMBtu
Low-Flow Showerhead with TSV, Gas (Residential End Use)			1.66
Low-Flow Showerhead with TSV, Electric (Residential End Use)	335.0	0.08	
Low-Flow Showerhead with TSV, Oil (Residential End Use)			1.88
Low-Flow Showerhead with TSV, Other (Residential End Use)			1.66

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 7 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Low-Flow Showerhead with TSV	CI_RETRO	All	7	n/a	n/a	7

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	0.81

In-Service Rates:

All installations have 100% in service rate.

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.[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 (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

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
Low-Flow Showerhead with TSV (Residential End Use)	CI_RETRO	All	$0.58					

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 : MA Common Assumptions.
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 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
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

3.61. 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 (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
Pipe Wrap (Water Heating), Gas, <= 1.5”	0.21
Pipe Wrap (Water Heating), Gas, 2"	0.36

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), Gas	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

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 are based on an evaluation study.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Pipe Wrap (Water Heating), 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 : 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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.62. Hot Water - Pipe Wrap (Water Heating) - C&I 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)	E19C2a080
Pipe Wrap (Water Heating), Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a060

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] kW savings are calculated using the demand impact model.

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.[2]

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	RRE	RRNE	RRSP	RRWP	CFSP	CFWP
Pipe Wrap (Water Heating), Electric (Residential End Use)	CI_RETRO	All	1.00	1.00	1.00	1.00	1.00	0.31	0.81
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:

Coincidence factors are estimated using the demand allocation methodology described in the Demand Impact Model.[3]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SOP	SONP	NTG
Pipe Wrap (Water Heating)(Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

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 : 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

3 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

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

3.63. 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	C&I Existing Building Retrofit (CI_RETRO)	G19C2a023
Pre-Rinse Spray Valve (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a044
Pre-Rinse Spray Valve - Upstream	C&I Existing Building Retrofit (CI_RETRO)	G19C2b044

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed and based on study results.[1]

Measure Name	ΔMMBtu
Spray Valve	11.4

Baseline Efficiency:

The baseline efficiency case is an existing efficiency spray valve.

High Efficiency:

The high efficiency case is a low flow pre-rinse spray valve with an average flow rate of 1.6 GPM.[2]

Measure Life:

The measure life is 8 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Spray Valve	CI_RETRO	All	8	n/a	n/a	8

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}
Spray Valve	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:

Values from 2018 C&I NTG study.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Spray Valve	CI_RETRO	All	0.22	0.03	0.00	0.80
Spray Valve - Upstream	CI_RETRO	All	0.24	0.07	0.00	0.83

Non-Energy Impacts:

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

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.
3 : DNV GL (2014). Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valves. DNVGL_2014_Impact_Evaluation_MA_2012_Gas_Pre-Rinse_Spray_Valve
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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.64. 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
Low-Flow Showerhead with TSV, Electric	C&I Existing Building Retrofit (CI_RETRO)	E19C2a041

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on engineering analysis.[1] kW savings are calculated using the demand impact model.[2]

Measure Name	ΔkWh	ΔkW
Showerheads with TSV	69	0.01

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
Showerheads with 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}
Showerheads with TSV	CI_Retro	All	1.00	1.00	n/a	1.00	1.00	0.52	1.00

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

Realization Rates:
All PAs use 100% energy and demand realization rates as deemed values are based on evaluation results.

Coincidence Factors:
Calculated from weighted average based on the demand impact model.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Showerheads with TSV	CI_RETRO	All	0.14	0.05	0.02	0.94

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 : 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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

3.65. 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)	G19C2a012

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 2018 C&I NTG study.[3]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Steam Trap	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 : 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 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.66. 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, On Demand, Gas - Upstream	C&I New & Replacement Equipment (CI_EQUIP)	G19C2b022

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed per unit.[1]

Measure Name	ΔMMBtu
Tankless Water Heater, Gas 0.94 - Upstream	8.9

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 on-demand tankless water heaters the baseline is a code-compliant gas-fired storage water heater with EF = 0.61.[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 96% 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 2018 C&I Upstream HVAC NTG study.[5]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	2019 NTG	2020 NTG	2021 NTG
Tankless Water Heater, Gas 0.94 - Upstream	CI_EQUIP	All	N/A	N/A	N/A	0.60	0.59	0.58

Non-Energy Impacts:

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

Endnotes:

1 : 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 However, baselines and savings have since been evaluated and adjustments for 2019 have been made by way of a RR adjustment. In 2020+, baselines and gross savings will be adjusted in accordance with the evaluation findings.
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 : 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 (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.

3.67. Hot Water - Thermostatic Valve - C&I 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)	E19C2a077
Thermostatic Shut-off Valve, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a078
Thermostatic Shut-off Valve, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a079
Thermostatic Shut-off Valve, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a065

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 7 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Thermostatic Shut-off Valve	CI_RETRO	All	7	n/a	n/a	7

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	0.81
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	0.21	0.13	0.17	1.09

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 : MA Common Assumptions
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 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation

3.68. Hot Water - Volume Water Heater

Measure Code	COM-WH-VWH
Market	Commercial
Program Type	Replace on Burnout
Category	Water Heating

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)	G19C2b027

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	0.6077

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). The assumed baseline is a code specified 80% 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	0.76	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 76% 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 2018 C&I Upstream HVAC NTG study.[5]

Measure Name	Core Initiative	PA	2019 NTG	2020 NTG	2021 NTG
Volume Water Heater, Gas 0.94 TE - Upstream	CI_EQUIP	All	0.60	0.59	0.58

Non-Energy Impacts:

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

Endnotes:

1 : Unit gross savings assumptions were developed by implementation in response to NTG findings going into the 2019-2021 planning cycle. Baselines and savings have been evaluated and adjustments for 2019 have been made by way of a RR adjustment. In 2020+, baselines and gross savings will be adjusted in accordance with the evaluation findings.
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; Appendix A-2. GDS_2007_Measure_Life_Report_Residential_and_CI_Lighting_and_HVAC_Measures
4 : DNV GL (2019). Upstream Water Heater Deemed Savings Impact Evaluation
5 : DNV GL (2018). C&I Upstream HVAC NTG Study.

3.69. Insulation - Residential End Use

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)	E19C2a061
Insulation, Central AC in Electrically-Heated Unit (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a062
Insulation, Oil (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a063
Insulation, Other (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a112
Insulation, Gas (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a056
Insulation, Gas, with Central AC (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	G19C2a057

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	0.35	0.00
Insulation, Gas (Residential End Use)	CI_RETRO	All	1.00	n/a	0.86	n/a	n/a	n/a	n/a

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation, Gas, with Central AC (Residential End Use)	CI_RETRO	All	1.00	1.00	0.86	1.00	1.00	0.35	0.00
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 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
Insulation (Residential End Use)	CI_RETRO	All	0.21	0.13	0.17	1.09

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
Insulation (Residential End Use)	CI_RETRO	All	$47.31					

Endnotes:

1 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
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 : Navigant Consulting (2018). Demand Impact Model Update.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report
6 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
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

3.70. Lighting - Commercial Multifamily

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 In Unit (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a092
LED Fixture, Outdoor In Unit (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a093
LED Fixture, Indoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a095
LED Fixture, Linear Indoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a096
LED Fixture, Outdoor Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a097
Occupancy Sensor, Common Area (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a098

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 Retrofit".

3.71. 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)	E19C1a020
Lighting Controls - Occupancy Sensor	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a021
Lighting Controls - Dual Sensor/Other	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a022
Lighting Controls - Exterior	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a023
Lighting Controls - Daylight Dimming	C&I Existing Building Retrofit (CI_RETRO)	E19C2a015
Lighting Controls - Occupancy Sensor	C&I Existing Building Retrofit (CI_RETRO)	E19C2a016
Lighting Controls - Dual Sensor/Other	C&I Existing Building Retrofit (CI_RETRO)	E19C2a017
Lighting Controls - Exterior	C&I Existing Building Retrofit (CI_RETRO)	E19C2a018
Lighting Controls - Interior (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a050
Lighting Controls - Exterior (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a051
Lighting Controls - Daylight Dimming	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b019

Measure Name	Core Initiative	BCR Measure ID
Lighting Controls - Occupancy Sensor	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b020
Lighting Controls - Dual Sensor/Other	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b021
Lighting Controls - Exterior	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b022

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]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Lighting Controls (All)	CI_NB&MR	All	0.397	0.028	0.034	0.665
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			$0.02			
Lighting Controls (All)	CI_RETRO	All			$0.03			
Lighting Controls (All)	CI_EQUIP	All						

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. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.72. 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
Lighting - Freezer/Cooler LED	C&I Existing Building Retrofit (CI_RETRO)	E19C2a030

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	2019	2020	2021
Freezer/Cooler LEDs	CI_RETRO	All	10.98	10.68	10.53

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	0.135	0.053	0.018	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

3.73. 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)	E19C1a014
Performance Lighting (Exterior)	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a015
Performance Lighting (Interior with Controls)	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a016
Performance Lighting (Exterior with Controls)	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a017
Performance Lighting (Interior)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a009
Performance Lighting (Exterior)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a010
Performance Lighting (Interior with Controls)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a011
Performance Lighting (Exterior with Controls)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a012
Performance Lighting (Interior)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b013
Performance Lighting (Exterior)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b014

Measure Name	Core Initiative	BCR Measure ID
Performance Lighting (Interior with Controls)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b015
Performance Lighting (Exterior with Controls)	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b016

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.[1]

Application	Core Initiative	PA	2019	2020	2021
Ambient Linear TLED	CI_EQUIP CI_RETRO	All	10.98	10.68	10.53
Ambient Linear Fixtures	CI_EQUIP CI_RETRO	All	11.39	11.13	10.99
High/Low Bay Lamps	CI_EQUIP CI_RETRO	All	13.02	12.73	12.56
High/Low Bay TLED	CI_EQUIP CI_RETRO	All	13.22	12.96	12.81
High/Low Bay Fixtures	CI_EQUIP CI_RETRO	All	13.25	12.99	12.84
Exterior/Outdoor Lamps	CI_EQUIP CI_RETRO	All	10.10	9.96	9.74
Exterior/Outdoor TLED	CI_EQUIP CI_RETRO	All	10.45	10.32	10.12
Exterior/Outdoor Fixtures	CI_EQUIP CI_RETRO	All	10.50	10.37	10.18
A-Lamps	CI_EQUIP CI_RETRO	All	4.99	4.82	4.69
Decoratives	CI_EQUIP CI_RETRO	All	4.07	3.99	3.78
Downlights/Track	CI_EQUIP CI_RETRO	All	5.89	5.88	5.86
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]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Performance Lighting (All)	CI_NB&MR	All	0.40	0.03	0.03	0.67
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			$0.02			
Performance Lighting	CI_RETRO	All			$0.03			
Performance Lighting	CI_EQUIP	All						

Endnotes:

1 : DNV GL, (2020). 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 : 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

3.74. 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)	E19C1a018
Lighting Systems - Exterior	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a019
Lighting Systems Interior	C&I Existing Building Retrofit (CI_RETRO)	E19C2a013
Lighting Systems Exterior	C&I Existing Building Retrofit (CI_RETRO)	E19C2a014
Lighting Systems - Interior (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a048
Lighting Systems - Exterior (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a049
Lighting Systems - Interior	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b017
Lighting Systems - Exterior	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b018
Lighting Upstream - LED Linear	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b058
Lighting Upstream - LED Screw In	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b059
Lighting Upstream - LED Stairwell	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b060

Measure Name	Core Initiative	BCR Measure ID
Lighting Upstream - LED Linear with Controls	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b061
Lighting Upstream - High Bay / Low Bay	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b062
Lighting Upstream - High Bay / Low Bay with Controls	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b096
Lighting Upstream - LED Exterior	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b063
Lighting Upstream - LED Linear Fixture	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b088

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = (\text{Summation } i=1 \text{ to } n(\text{Count}_i * \text{Watts}_i / 1000)_{BASE} - \text{Summation } j=1 \text{ to } n(\text{Count}_j * \text{Watts}_j / 1000)_{EE}) \text{ (Hours)}$
$\Delta kW = \text{Summation } i=1 \text{ to } n(\text{Count}_i * \text{Watts}_i / 1000)_{BASE} - \text{Summation } j=1 \text{ to } n (\text{Count}_j * \text{Watts}_j / 1000)_{EE}$

Where:
n = Total number of fixture types in baseline or pre-retrofit case
m = Total number of installed fixture types
$Count_i$ = 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 2019-2021 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	4,839
Grocery/Food Sales	5,468
Hospital	5,413
Industrial/Manufacturing	4,988
K-12 School	2,788

Building Type	Hours of Use
Lodging	4,026
Medical Office	3,673
Office Building	4,181
Other	4,332
Restaurant/Food Service	5,018
Retail	4,939
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

Building Type	Hours of Use
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.[2]

Application	Core Initiative	PA	2019	2020	2021
Ambient Linear TLED	CI_EQUIP CI_RETRO	All	10.98	10.68	10.53
Ambient Linear Fixtures	CI_EQUIP CI_RETRO	All	11.39	11.13	10.99
High/Low Bay Lamps	CI_EQUIP CI_RETRO	All	13.02	12.73	12.56
High/Low Bay TLED	CI_EQUIP CI_RETRO	All	13.22	12.96	12.81

Application	Core Initiative	PA	2019	2020	2021
High/Low Bay Fixtures	CI_EQUIP CI_RETRO	All	13.25	12.99	12.84
Exterior/Outdoor Lamps	CI_EQUIP CI_RETRO	All	10.10	9.96	9.74
Exterior/Outdoor TLED	CI_EQUIP CI_RETRO	All	10.45	10.32	10.12
Exterior/Outdoor Fixtures	CI_EQUIP CI_RETRO	All	10.50	10.37	10.18
A-Lamps	CI_EQUIP CI_RETRO	All	4.99	4.82	4.69
Decoratives	CI_EQUIP CI_RETRO	All	4.07	3.99	3.78
Downlights/Track	CI_EQUIP CI_RETRO	All	5.89	5.88	5.86
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

Measure Name	Core Initiative	PA	MMBtu/kWh
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

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	0.78	0.78	0.88	0.75	0.83	0.65
Lighting Upstream – LED Screw In	CI_EQUIP	All	1.00	0.78	0.78	0.90	0.72	0.70	0.49
Lighting Upstream – LED Stairwell	CI_EQUIP	All	1.00	0.76	0.76	0.77	0.76	0.82	0.82
Lighting Upstream – LED Linear w/ Controls	CI_EQUIP	All	1.00	0.78	0.78	0.88	0.75	0.83	0.65
Lighting Upstream – High/Low Bay	CI_EQUIP	All	1.00	0.78	0.78	0.88	0.75	0.83	0.65
Lighting Upstream – LED Exterior	CI_EQUIP	All	1.00	0.68	0.78	0.76	0.76	0.00	1.00

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Lighting Upstream – High/Low Bay w/ Controls	CI_EQUIP	All	1.00	0.78	0.78	0.88	0.75	0.83	0.65

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. All factors come from the 2017 study, with the exception of in-service rates.[7]
- ISRs are from the 2018 follow-on study.[8]
- 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.[9]
- 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.[10]

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.[11]
- C&I Upstream: All PAs CFs are from the 2017 Upstream Lighting Impact evaluation.[12]
- C&I Existing Building Retrofit: All CFs are from 12 month logging impact evaluation of MA PAs LCI prescriptive lighting programs.[13]
- 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.[14]

Impact Factors for Calculating Net Savings:

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

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Lighting System – Interior	CI_NB&MR	All	0.397	0.028	0.034	0.665
Lighting System – Exterior	CI_NB&MR	All	0.397	0.028	0.034	0.665
Lighting System – Interior (Turnkey)	CI_RETRO	All	0.135	0.053	0.018	0.936
Lighting System – Exterior (Turnkey)	CI_RETRO	All	0.135	0.053	0.018	0.936

Lighting System – Interior	CI_RETRO	All	0.135	0.053	0.018	0.936
Lighting System – Exterior	CI_RETRO	All	0.135	0.053	0.018	0.936
Lighting System – Interior	CI_EQUIP	All	0.225	0.085	0.000	0.860
Lighting System – Exterior	CI_EQUIP	All	0.225	0.085	0.000	0.860

Upstream Net-to-Gross for 2019

Upstream lighting NTG are per the 2018 upstream lighting NTG study.[16]

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Lighting Upstream – LED Linear	CI_EQUIP	All	0.34	0.14	0.00	0.80
Lighting Upstream – LED Screw In	CI_EQUIP	All	0.50	0.23	0.00	0.73
Lighting Upstream – LED Stairwell	CI_EQUIP	All	0.34	0.14	0.00	0.80
Lighting Upstream – LED Linear w/ Controls	CI_EQUIP	All	0.34	0.14	0.00	0.80
Lighting Upstream – High/Low Bay	CI_EQUIP	All	0.34	0.14	0.00	0.80
Lighting Upstream – LED Exterior	CI_EQUIP	All	0.34	0.14	0.00	0.80
Lighting Upstream - High/Low Bay w/Controls	CI_EQUIP	All	0.34	0.14	0.00	0.80

Non-Energy Impacts:

New Construction non-energy benefits come from the 2016 NEI study.[17] Retrofit non-energy benefits come from the 2012 NEI study.[18]

Measure Name	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			$0.02			
Lighting Systems - Exterior	CI_NB&MR, CI_EQUIP	All			$0.02			
Lighting Systems - Interior	CI_RETRO	All			$0.03			
Lighting Systems - Exterior	CI_RETRO	All			$0.03			
Lighting Systems – Interior (Turnkey)	CI_RETRO	All			$0.03			

Measure Name	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 – Exterior (Turnkey)	CI_RETRO	All			$0.03			
Lighting Upstream – LED Linear	CI_EQUIP	All						
Lighting Upstream – LED Screw In	CI_EQUIP	All			$0.03			
Lighting Upstream – LED Stairwell	CI_EQUIP	All						
Lighting Upstream – LED Linear w/ Controls	CI_EQUIP	All						
Lighting Upstream – High/Low Bay	CI_EQUIP	All						
Lighting Upstream – LED Exterior	CI_EQUIP	All						
Lighting Upstream - High/Low Bay w/Controls	CI_EQUIP	All						

Endnotes:

1 : DNV GL (2018). Massachusetts C&I Lighting Hours of Use by Building Type - Quick Hit Study. 2019_DNVGL_Ltg_HOU. Parking garage hours of use not output of evaluation and only used for applications subject to 24/7 usage per code requirements.
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 : 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 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 : DNV GL (2017). Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative. DNVGL_2017_Upstream_Lighting_Impact_Evaluation
8 : DNV GL (2018). MA C&I Upstream Lighting In-Service Rate (ISR) Analysis Summary.
9 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. DNV_KEMA_2013_Prescriptive_Ltg_Impact_Eval_PY2010
10 : DNV GL (2018). Impact Evaluation of PY2016 Massachusetts Commercial & Industrial Small Business Initiative: Phase I (Lighting). 2018_DNVGL_ERS_SBS_Impact
11 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. DNV_KEMA_2013_Prescriptive_Ltg_Impact_Eval_PY2010
12 : DNV GL (2017). Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative. DNVGL_2017_Upstream_Lighting_Impact_Evaluation
13 : DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. DNV_KEMA_2013_Prescriptive_Ltg_Impact_Eval_PY2010
14 : DNV GL (2018). Impact Evaluation of PY2016 Massachusetts Commercial & Industrial Small Business Initiative: Phase I (Lighting). 2018_DNVGL_ERS_SBS_Impact
15 : NMR (2018). Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
16 : DNV GL (2018). C&I Upstream Lighting Net-to-Gross Study. 2018_DNVGL_Upstream_Ltg_NTG
17 : Tetra Tech (2016). C&I New Construction Non-Energy Impacts Study. DNVGL_2016_CI_NC_NEI
18 : Tetra Tech (2012). C&I Retrofit Non-Energy Impacts Study. TETRATECH_2012_MA_CI_NEI_REPORT

3.75. Motor - Variable Frequency Drive

Measure Code	COM-MAD-VFD
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
VFD - Prescriptive	C&I Existing Building Retrofit (CI_RETRO)	E19C2a021
VFD - Prescriptive (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a054

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)	University/ College	3641	449	745	2316	2344	3220	1067	1023	3061
Annual Energy Savings Factors (kWh/HP)	Elem/High School	3563	365	628	1933	1957	3402	879	840	2561
Annual Energy Savings Factors (kWh/HP)	Multi-Family	3202	889	1374	2340	2400	3082	1374	1319	3713
Annual Energy Savings Factors (kWh/HP)	Hotel/ Motel	3151	809	1239	2195	2239	3368	1334	1290	3433
Annual Energy Savings Factors (kWh/HP)	Health	3375	1705	2427	2349	2406	3002	1577	1487	3670

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)	Warehouse	3310	455	816	2002	2087	3229	1253	1205	2818
Annual Energy Savings Factors (kWh/HP)	Restaurant	3440	993	1566	1977	2047	2628	1425	1363	3542
Annual Energy Savings Factors (kWh/HP)	Retail	3092	633	1049	1949	2000	2392	1206	1146	2998
Annual Energy Savings Factors (kWh/HP)	Grocery	3126	918	1632	1653	1681	2230	1408	1297	3285
Annual Energy Savings Factors (kWh/HP)	Offices	3332	950	1370	1866	1896	3346	1135	1076	3235
Summer Demand	University/ College	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218

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
Savings Factors (kW/HP_{SP})										
Summer Demand Savings Factors (kW/HP_{SP})	Elm/H School	0.377	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
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
Summer Demand Savings Factors (kW/HP_{SP})	Hotel/ Motel	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Summer Demand Savings Factors (kW/HP_{SP})	Health	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Summer Demand Savings	Warehouse	0.109	-0.023	0.174	0.457	0.091	0.261	0.287	0.274	0.218

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
Factors (kW/HP_{SP})										
Summer Demand Savings Factors (kW/HP_{SP})	Restaurant	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Summer Demand Savings Factors (kW/HP_{SP})	Retail	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Summer Demand Savings Factors (kW/HP_{SP})	Grocery	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Summer Demand Savings Factors (kW/HP_{SP})	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

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
Winter Demand Savings Factors (kW/HP_{WP})	Elementary /High School	0.457	-0.006	0.184	0.457	0.21	0.109	0.26	0.252	0.282
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
Winter Demand Savings Factors (kW/HP_{WP})	Hotel/Motel	0.109	-0.006	0.184	0.418	0.21	0.109	0.26	0.252	0.282
Winter Demand Savings Factors (kW/HP_{WP})	Health	0.377	-0.006	0.184	0.275	0.21	0.109	0.26	0.252	0.282
Winter Demand Savings Factors (kW/HP_{WP})	Warehouse	0.377	-0.006	0.184	0.178	0.21	0.261	0.26	0.252	0.282
Winter Demand	Restaurant	0.109	-0.006	0.184	0.355	0.21	0.109	0.26	0.252	0.282

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
Savings Factors (kW/HP_{WP})										
Winter Demand Savings Factors (kW/HP_{WP})	Retail	0.109	-0.006	0.184	0.275	0.21	0.109	0.26	0.252	0.282
Winter Demand Savings Factors (kW/HP_{WP})	Grocery	0.457	-0.006	0.184	0.418	0.21	0.109	0.26	0.252	0.282
Winter Demand Savings Factors (kW/HP_{WP})	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:

For lost-opportunity installations, the lifetime is 15 years.[3] 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
All VFD - prescriptive	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 - prescriptive	CI_RETRO	All	1.00	0.94	n/a	1.00	1.00	1.00	1.00
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 RRs for non-residential end use installations 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 RRs for residential end use installations based on an evaluation of multi family projects.[6]
- Energy and Demand RRs for Turnkey installations are based on the Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures study [7] .

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.[8] Residential end use installations based on evaluation of multi family projects.[9]

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
VFD - Prescriptive	CI_RETRO	All	0.13	0.05	0.02	0.94

Non-Energy Impacts:

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

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
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 : KEMA, Inc. and DMI, Inc. (2013). 2011-2012 Massachusetts Prescriptive VSD Impact Evaluation.
KEMA_2013_Prescriptive_VSD_Report
6 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Multifamily_Program_Impact_Evaluation
7 : DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.
8 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
9 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation.
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

3.76. 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
Motors & VFD - Custom (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a109

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 (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
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	0.21	0.13	0.17	1.09

Non-Energy Impacts:

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

Endnotes:

1 : Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at 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 : 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 : Navigant Consulting (2018). Multi-Family Program Impact and Net-to-Gross Evaluation. 2018_Navigant_Multifamily_Program_Impact_Evaluation

3.77. 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
VFD with Motor - Prescriptive	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a025
VFD with Motor - Prescriptive	C&I Existing Building Retrofit (CI_RETRO)	E19C2a020
VFD with Motor - Prescriptive (Turnkey)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a055
VFD with Motor - Prescriptive	C&I New & Replacement Equipment (CI_EQUIP)	E19C2b024

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 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
Elem/High 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
Elem/High 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

	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**
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.[7]

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

Non-Energy Impacts:

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

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.
7 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

3.78. Other - Code Compliance Support Initiative (CCSI)

Measure Code	COM-CM-CCSI
Market	Commercial
Program Type	Custom
Category	Custom

Measure Description:

The Mass Save Code Compliance Support Initiative (CCSI) is focused on improving the energy code compliance rates of residential and commercial buildings in the state. The initiative includes trainings, technical support, and the development of compliance documentation tools. This effort will support code officials, as well as design and construction professionals.

BCR Measure IDs:

Measure Name	Core Initiative	BCR Measure ID
Other - Codes and Standards Compliance Education	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a052
Other - Codes and Standards Compliance Education	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a008

Algorithms for Calculating Primary Energy Impact:

$$Program\ Net\ Savings_{year} = Program\ Attribution_{year} \times Gross\ Technical\ Potential_{year}$$

Where:
Gross Technical Potential - Commercial energy savings (kWh and Therms) through building simulations described below under Baseline Efficiency. The gross technical potential for C&I is the difference between site observed energy measures and buildings modelled as 100% compliant with 2012 IECC requirements multiplied by the total square feet of new commercial buildings in MA

Attribution Factor - The percentage of potential energy savings above the normal compliance level, on average, at the end of a typical energy code cycle attributable to PA CCSI efforts.

Savings are based on an evaluation study.[1]

Electric Savings (MWh)

PA	2019	2020	2021
Cape Light Compact	406.7	576.3	585.0
Eversource	2,390.8	3,387.9	3,439.1

PA	2019	2020	2021
National Grid	2,435.4	3,451.1	3,503.2
Unitil	65.1	92.3	93.6

Gas Penalty for Stricter Lighting Compliance (therms)

PA	2019	2020	2021
Cape Light Compact	-1,322.0	-1,873.2	-1,901.6
Eversource	-7,772.0	-11,012.3	-11,179.1
National Grid	-7,916.8	-11,217.6	-11,387.4
Unitil	-211.6	-299.9	-304.4

Gas Savings (therms)

PA	2019	2020	2021
Berkshire Gas	448.6	635.6	645.3
CMA	2,216.7	3,141.0	3,188.6
Eversource	1,960.9	2,778.6	2,820.6
Liberty Utilities	316.1	447.9	454.7
National Grid	6,009.23	8,515.0	8,643.9
Unitil	141.5	200.5	203.5

Baseline Efficiency:

The baseline case is based on a Delphi panel estimate of the level of code compliance over the 2019-2021 period had the CCSI never been implemented. This level of compliance was subsequently adjusted to the mid-point of the with and without CCSI compliance value to reflect the baseline compliance had the CCSI been discontinued after 2018. The corresponding building level energy use for the buildings at this lower level of code compliance was taken as the baseline.

High Efficiency:

The high efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code.

Measure Life:

The measure life is 20 years.

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Other - Codes and Standards Compliance Education	CI_NB&MR	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}
Other - Codes and Standards Compliance Education	CI_NB&MR	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 as all adjustments are made via the factors listed in the algorithm above.

Coincidence Factors:
Per Statewide agreement, kW will not be claimed for this measure.

Impact Factors for Calculating Net Savings:

All PAs use 100% net-to-gross factor, as the savings presented above are net savings.

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Other - Codes and Standards Compliance Education	CI_NB&MR	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. (2018). Massachusetts Non-Residential Code Compliance Support Initiative Attribution and Net Savings Assessment 2018_NMR_NonRes_CCSI_Attribution_Assessment

3.79. Other - Codes and Standards Advocacy

Measure Code	COM-CM-CSA
Market	Commercial
Program Type	Custom
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
Other - Codes and Standards Advocacy	C&I New Buildings & Major Renovations (CI_NB&MR)	E19C1a053
Other - Codes and Standards Advocacy	C&I New Buildings & Major Renovations (CI_NB&MR)	G19C1a034

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.

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
Other - Codes and Standards Advocacy	CI_NB&MR	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}
Other - Codes and Standards Advocacy	CI_NB&MR	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
Other - Codes and Standards Advocacy	CI_NB&MR	All	0.00	0.00	0.00	1.00

Non-Energy Impacts:

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

3.80. 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)	E19C2a099

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

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.[2]

Other Resource 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	0.76	0.92	0.92	0.92	0.58	0.86

In-Service Rates:

In-service rates are based on consumer surveys, as found in the referenced study.[3]

Realization Rates:

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[4]

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Navigant Demand Impact Model.[5]

Impact Factors for Calculating Net Savings:

Measure Name	Core Initiative	PA	NTG
Smart Strip	CI_RETRO	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 : Massachusetts Common Assumption
3 : NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study. NMR_2018_Products_ISR_Study
4 : NMR Group, Inc. (2018). Advanced Power Strip Metering Study. 2018_NMR_APS_Metering_Report
5 : Navigant Consulting (2018). Demand Impact Model Update. 2018_Navigant_Baseline_Loadshape_Comprehensive_Report

3.81. 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)	E19C2a037

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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Case Motor Replacement	CI_RETRO	ES, CLC	1.00	0.91	n/a	0.92	0.92	1.00	1.00
Refrigeration - Case Motor Replacement	CI_RETRO	NGRID, Unitil	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:

- National Grid: set to 100% since changes to calculation methodology based on 2005 Custom SBS evaluation.[7]
- Unitil: RRs set to 100% based on no evaluations.
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit impact evaluations.

Coincidence Factors:

All PAs set coincident factors to 1.00 since demand savings are average.

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	0.14	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 - Case Motor Replacement	CI_RETRO	All			$0.047			

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
7 : RLW Analytics (2007). Impact Evaluation Analysis of the 2005 Custom SBS Program. Prepared for National Grid. RLW_2007_Small_Business_Services_Custom_Measure_Impact_Evaluation
8 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
9 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study.
TETRATECH_2012_MA_CI_NEI_REPORT

3.82. 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)	E19C2a034

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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration -Door Heater Controls	CI_RETRO	National Grid, Unitil	1.00	1.00	n/a	1.00	1.00	0.50	1.00
Refrigeration -Door Heater Controls	CI_RETRO	Eversource, CLC	1.00	0.91	n/a	0.92	0.92	0.50	1.00

In-Service Rates:

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

Realization Rates:

- National Grid, Unitil: energy RR based on staff estimates.
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.

Coincidence Factors:

All PAs: on-peak CFs from the 1995 HEC study of walk-in cooler anti-sweat door heater controls.[6]

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 - 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.[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 - Door Heater Controls	CI_RETRO	All			$0.047			

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
6 : HEC, Inc. (1995). Analysis of Door Master Walk-In Cooler Anti-Sweat Door Heater Controls Installed at Ten Sites in Massachusetts. Prepared for New England Power Service Company; Table 9. Adjusted to account for updated RR. HEC_1995_Analysis_of_Door_Master_Walk-In_Cooler_Anti-Sweat_Door_Heat_Controls
7 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
8 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study. TETRATECH_2012_MA_CI_NEI_REPORT

3.83. 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)	E19C2a036

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	RRE	RRNE	RRSP	RRWP	CFSP	CFWP
Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers	CI_RETRO	NGRID, Unitil	1.00	1.00	n/a	1.00	1.00	1.00	1.00
Refrigeration - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers	CI_RETRO	ES, CLC	1.00	0.91	n/a	0.92	0.92	1.00	1.00

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

Realization Rates:

- National Grid: RRs set to 100% since changes to calculation methodology made based on 2005 Custom SBS program evaluation.[7]
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.

Coincidence Factors:

Coincident factors are set to 1 since demand savings is average.

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 - 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.[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 - ECM Evaporator Fan Motors for Walk-in Coolers and Freezers	CI_RETRO	All			$0.047			

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
7 : RLW Analytics (2007). Impact Evaluation Analysis of the 2005 Custom SBS Program. Prepared for National Grid RLW_2007_Small_Business_Services_Custom_Measure_Impact_Evaluation
8 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
9 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study.
TETRATECH_2012_MA_CI_NEI_REPORT

3.84. 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)	E19C2a039

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh_{Defrost} = kW_{Defrost}$ x Hours x DRF
$\Delta kWh_{Heat} = \Delta kWh_{Defrost}$ x0.28 xEff_{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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Electronic Defrost Control	CI_RETRO	National Grid Unitil	1.00	1.00	n/a	1.00	1.00	1.00	1.00
Refrigeration - Electronic Defrost Control	CI_RETRO	Eversource CLC	1.00	0.91	n/a	0.92	0.92	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, Unitil: RRs set to 100% based on no evaluations.
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors:

All PAs set coincident factors to 1.00 since demand savings are average.

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.[6]

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.[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
Refrigeration - Electronic Defrost Control	CI Retro	All			$0.047			

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
6 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
7 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study.
TETRATECH_2012_MA_CI_NEI_REPORT

3.85. 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)	E19C2a040

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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Evaporator Fan Controls	CI_RETRO	National Grid Unitil	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Refrigeration - Evaporator Fan Controls	CI_RETRO	Eversource CLC	1.00	0.91	0.91	0.92	0.92	1.00	1.00

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

Realization Rates:

- National Grid set to 100% after small retrofit RRs from 1996 savings analysis[10] suggestions for more accurate calculations adopted.
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.

Coincidence Factors:

All PAs set coincident factors to 1.00 since demand savings are average.

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.[11]

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.[12]

Measure Name	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			$0.047			

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
10 : HEC, Inc. (1996). Analysis of Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls. Prepared for New England Power Service Company.
HEC_1996_Analysis_of_Savings_from_Walkin_Cooler_Air_Economizers_and_Evap_Fan_Controls
11 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
12 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study.
TETRATECH_2012_MA_CI_NEI_REPORT

3.86. 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)	E19C2a035

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 measure 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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigeration - Novelty Cooler Shutoff	CI_RETRO	National Grid Unitil	1.00	1.00	n/a	1.00	1.00	1.00	1.00
Refrigeration - Novelty Cooler Shutoff	CI Retro	Eversource CLC	1.00	0.91	0.91	0.92	0.92	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: energy RR based on staff estimates.
- Eversource, CLC: RRs based on NSTAR 2002-2004 small retrofit impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.

Coincidence Factors:

Coincidence factors are set to zero since demand savings typically occur during off-peak hours.

Impact Factors for Calculating Net Savings:

All PAs use statewide prescriptive net-to-gross results.[6]

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.[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
Refrigeration - Novelty Cooler Shutoff	CI_RETRO	All			$0.047			

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
6 : NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report
7 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study.
TETRATECH_2012_MA_CI_NEI_REPORT

3.87. 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)	E19C2a031
Vending Miser - Non-Refrigerated Beverage Vending Machines	C&I Existing Building Retrofit (CI_RETRO)	E19C2a032
Vending Miser - Glass Front Refrigerated Coolers	C&I Existing Building Retrofit (CI_RETRO)	E19C2a033
Vending Miser (Residential End Use)	C&I Existing Building Retrofit (CI_RETRO)	E19C2a107

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = (kW_{rated})(Hours)(SAVE)$
$\Delta kW = \Delta kWh / Hours$

Where:
kW_{rated} = Rated kW of connected equipment. See for default rated kW by connected equipment type.
Hours = Operating hours of the connected equipment: default of 8,760 hours
SAVE = Percent savings factor for the connected equipment. See table below for values.

Vending Machine and Cooler Controls Savings Factors[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	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
All Vending Misers	CI_RETRO	National Grid Unitil	1.00	1.00	1.00	1.00	1.00	0.00	0.00
All Vending Misers	CI_RETRO	Eversource CLC	1.00	0.85	0.85	0.41	0.24	0.00	0.00

In-Service Rates:

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

Realization Rates:

- National Grid, Unitil: RRs set to 100% since savings estimated are based on study results.
- Eversource, CLC: C&I Existing Building Retrofit RRs from impact evaluation of NSTAR 2006 refrigeration installations ; small retrofit RRs from impact evaluation of 2002 program year[3]

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.[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
All Vending Misers	CI_RETRO	All			$0.047			

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

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 : 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

6 : KEMA (2012). Final Report - Commercial and Industrial Non-Energy Impacts Study. TETRATECH_2012_MA_CI_NEI_REPORT

Appendices

Appendix A: Common Lookup Tables

Table 1: Lighting Power Densities Using the Building Area Method[2]

Building Area Type	Lighting Power Density (W/ft^2)
Automotive facility	0.80
Convention center	1.01
Courthouse	1.01
Dining: bar lounge/leisure	1.01
Dining: cafeteria/fast food	0.9
Dining: family	0.95
Dormitory	0.57
Exercise center	0.84
Fire station	0.67
Gymnasium	0.94
Health care clinic	0.90
Hospital	1.05
Hotel/Motel	0.87
Library	1.19
Manufacturing facility	1.17
Motion picture theater	0.76
Multifamily	0.51
Museum	1.02
Office	0.82
Parking garage	0.21
Penitentiary	0.81
Performing arts theater	1.39
Police station	0.87
Post office	0.87
Religious building	1.0
Retail	1.26
School/university	0.87
Sports arena	0.91
Town hall	0.89
Transportation	0.70
Warehouse	0.66
Workshop	1.19

[2] IECC 2015 Interior Lighting Power Allowances: Building Area method, Table C405.4.2(1)

Table 2: Interior Lighting Power Allowances: Space-by-Space Method[3]

Space Type	Lighting Power Density (W/ft^2)
COMMON SPACE-BY-SPACE TYPES	
Atrium	
First 40 feet in height	0.03 per ft. ht.
Above 40 feet in height	0.40 + 0.02 per ft. ht.
Audience seating area	
In an auditorium	0.63
In a convention center	0.82
In a gymnasium	
In a motion picture theater	1.14
In a penitentiary	0.28
In a performing arts theater	2.43
In a religious building	1.53
In a sports arena	0.43
Otherwise	0.43
Banking activity area	1.01
Breakroom (See Lounge/breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	1.34
Otherwise	1.24
Conference/meeting/multipurpose	1.23
Copy/print room	0.72
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.92
In a hospital	0.79
In a manufacturing facility	0.41
Otherwise	0.66
Courtroom	1.72
Computer room	1.71
Dining Area	
In a penitentiary	0.96
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.9
In a bar/lounge or leisure dining	1.07
In a cafeteria or fast food dining	0.65
In family dining	0.89
Otherwise	0.65
Electrical/mechanical room	0.95
Emergency vehicle garage	0.56
Food preparation area	1.21
Guest Room	0.47
Laboratory	
In or as a classroom	1.43

[3] IECC 2015 Interior Lighting Power Allowances: Space-by-Space Method, Table C405.4.2(2)

Space Type	Lighting Power Density (W/ft^2)
Otherwise	1.81
Laundry/washing area	0.6
Loading dock, interior	0.47
Lobby	
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.8
For an elevator	0.64
In a hotel	1.06
In a motion picture theater	0.59
In a performing arts theater	2.0
Otherwise	0.9
Locker room	0.75
Lounge/breakroom	
In a healthcare facility	0.92
Otherwise	0.73
Office	
Enclosed	1.11
Open plan	0.98
Parking area, interior	0.19
Pharmacy area	1.68
Restroom	
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.21
Otherwise	0.98
Sales area	1.59
Seating area. general	0.54
Stairway (See space containing stairway)	
Stairwell	0.69
Storage room	0.63
Vehicular maintenance area	0.67
Workshop	1.59
BUILDING SPECIFIC SPACE-BY-SPACE TYPES	
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	2.21
In a recreation room (and not used primarily by the staff)	2.41
Automotive (See Vehicular maintenance area above)	
Convention center- exhibit space	1.45
Dormitory- living quarters	0.38
Fire station- sleeping quarters	0.22
Gymnasium/fitness center	
In an exercise area	0.72
In a playing area	1.2
Healthcare facility	
In an exam/treatment room	1.66

Space Type	Lighting Power Density (W/ft^2)
In an imaging room	1.51
In a medical supply room	0.74
In a nursery	0.88
In a nurse's station	0.71
In an operating room	2.48
In a patient room	0.62
In a physical therapy room	0.91
In a recovery room	1.15
Library	
In a reading area	1.06
In the stacks	1.71
Manufacturing facility	
In a detailed manufacturing area	1.29
In an equipment room	0.74
In an extra high bay area (greater than 50' floor-to-ceiling height)	1.05
In a high bay area (25 – 50' floor-to-ceiling height)	1.23
In a low bay area (less than 25' floor-to-ceiling height)	1.19
Museum	
In a general exhibition area	1.05
In a restoration room	1.02
Performing arts theater- dressing room	0.61
Post office- sorting area	0.94
Religious building	
In a fellowship hall	0.64
In a worship/pulpit/choir area	1.53
Retail facilities	
In a dressing/fitting room	0.71
In a mall concourse	1.1
Sports arena- playing area	
For a class I facility	3.68
For a class II facility	2.4
For a class III facility	1.8
For a class IV facility	1.2
Transportation facility	
In a baggage/carousel area	0.53
In an airport concourse	0.36
At a terminal ticket counter	0.8
Warehouse	
For medium to bulky, palletized items	0.58
For smaller, hand-carried items	0.95

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 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
1L027	27 WATT LED	27
1L028	28 WATT LED	28
1L029	29 WATT LED	29
1L030	30 WATT LED	30
1L031	31 WATT LED	31
1L032	32 WATT LED	32
1L033	33 WATT LED	33
1L034	34 WATT LED	34
1L035	35 WATT LED	35
1L036	36 WATT LED	36
1L037	37 WATT LED	37
1L038	38 WATT LED	38
1L039	39 WATT LED	39
1L040	40 WATT LED	40
1L041	41 WATT LED	41
1L042	42 WATT LED	42
1L043	43 WATT LED	43
1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46

1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L053	53 WATT LED	53
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L063	63 WATT LED	63
1L071	71 WATT LED	71
1L070	70 WATT LED	70
1L073	73 WATT LED	73
1L075	75 WATT LED	75
1L080	80 WATT LED	90
1L085	85 WATT LED	85
1L090	90 WATT LED	90
1L095	95 WATT LED	95
1L100	100 WATT LED	100
1L101	101 WATT LED	101
1L106	106 WATT LED	106
1L107	107 WATT LED	107
1L116	116 WATT LED	116
1L120	120 WATT LED	120
1L125	125 WATT LED	125
1L130	130 WATT LED	130
1L131	131 WATT LED	131
1L135	135 WATT LED	135
1L139	139 WATT LED	139
1L140	140 WATT LED	140
1L145	145 WATT LED	145
1L150	150 WATT LED	150
1L155	155 WATT LED	155
1L160	160 WATT LED	160
1L164	164 WATT LED	164
1L165	165 WATT LED	165
1L170	170 WATT LED	170
1L175	175 WATT LED	175
1L180	180 WATT LED	180
1L185	185 WATT LED	185
1L186	186 WATT LED	186
1L190	190 WATT LED	190
1L200	200 WATT LED	200
1L204	204 WATT LED	204
1L205	205 WATT LED	205
1L210	210 WATT LED	210
1L211	211 WATT LED	211
1L220	220 WATT LED	220
1L233	233 WATT LED	233
1L235	235 WATT LED	235

1L237	237 WATT LED	237
1L240	240 WATT LED	240
1L256	256 WATT LED	256
1L279	279 WATT LED	279

Table 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
2F50HSE	2L4’ 50W T5HO/ELIG	110
2F54HSE	2L4’ 54W T5HO/ELIG	117
3F14SSE	3L2’ 14W T5/ELIG	50
3F24HSE	3L4’ T5HO/ELIG	80
3F28SSE	3L4’ 28W T5/ELIG	95
3F47HSE	3L4’ 47W T5HO/ELIG	157
3F50HSE	3L4’ 50W T5HO/ELIG	168
3F54HSE	3L4’ 54W T5HO/ELIG	177
4F14SSE	4L2’ 14W T5/ELIG	68
4F28SSE	4L4’ 28W T5/ELIG	126
4F47HSE	4L4’ 47W T5HO/ELIG	200
4F50HSE	4L4’ 50W T5HO/ELIG	215
4F54ESH	4L4’ 54W T5HO/ELEE	218
Device Code	**Device Description**	**Rated Watts**
T5 Systems (cont.)		
4F54HSE	4L4’ 54W T5HO/ELIG	234
5F47HSE	5L4’ 47W T5HO/ELIG	260
5F50HSE	5L4’ 50W T5HO/ELIG	278
5F54HSE	5L4’ 54W T5HO/ELIG	294
6F28SSE	6L4’ 28W T5/ELIG	189
6F47HSE	6L4’ 47W T5HO/ELIG	303
6F50HSE	6L4’ 50W T5HO/ELIG	325
6F54HSE	6L4’ 54W T5HO/ELIG	351
8F54HSE	8L4’ 54W T5HO/ELIG	468
10F54HSE	10L4’ 54W T5HO/ELIG	585
Two Foot High Efficient T8 Systems		
1F17ESL	1L2’ 17W T8EE/ELEE LOW PWR	14
1F17ESN	1L2’ 17W T8EE/ELEE	17
1F17ESH	1L2’ 17W T8EE/ELEE HIGH PWR	20
1F28BXE	1L2’ F28BX/ELIG	32
2F17ESL	2L2’ 17W T8EE/ELEE LOW PWR	27
2F17ESN	2L2’ 17W T8EE/ELEE	32
2F17ESH	2L2’ 17W T8EE/ELEE HIGH PWR	40
2F28BXE	2L2’ F28BX/ELIG	63
3F17ESL	3L2’ 17W T8EE/ELEE LOW PWR	39
3F17ESN	3L2’ 17W T8EE/ELEE	46
3F17ESH	3L2’ 17W T8EE/ELEE HIGH PWR	61
3F28BXE	3L2’ F28BX/ELIG	94
Three Foot High Efficient T8 Systems		
1F25ESL	1L3’ 25W T8EE/ELEE LOW PWR	21
1F25ESN	1L3’ 25W T8EE/ELEE	24
1F25ESH	1L3’ 25W T8EE/ELEE HIGH PWR	30
2F25ESL	2L3’ 25W T8EE/ELEE LOW PWR	40
Device Code	**Device Description**	**Rated Watts**
Three Foot High Efficient T8 Systems (cont.)		
2F25ESN	2L3’ 25W T8EE/ELEE	45

2F25ESH	2L3’ 25W T8EE/ELEE HIGH PWR	60
3F25ESL	3L3’ 25W T8EE/ELEE LOW PWR	58
3F25ESN	3L3’ 25W T8EE/ELEE	67
3F25ESH	3L3’ 25W T8EE/ELEE HIGH PWR	90
Four Foot T8 High Efficient / Reduce Wattage Systems		
1F25EEH	1L4’ 25W T8EE/ELEE HIGH PWR	30
1F25EEE	1L4’ 25W T8EE/ELEE	22
1F25EEL	1L4’ 25W T8EE/ELEE LOW PWR	19
2F25EEH	2L4’ 25W T8EE/ELEE HIGH PWR	57
2F25EEE	2L4’ 25W T8EE/ELEE	43
2F25EEL	2L4’ 25W T8EE/ELEE LOW PWR	37
3F25EEH	3L4’ 25W T8EE/ELEE HIGH PWR	86
3F25EEE	3L4’ 25W T8EE/ELEE	64
3F25EEL	3L4’ 25W T8EE/ELEE LOW PWR	57
4F25EEH	4L4’ 25W T8EE/ELEE HIGH PWR	111
4F25EEE	4L4’ 25W T8EE/ELEE	86
4F25EEL	4L4’ 25W T8EE/ELEE LOW PWR	75
1F28EEH	1L4’ 28W T8EE/ELEE HIGH PWR	33
1F28EEE	1L4’ 28W T8EE/ELEE	24
1F28EEL	1L4’ 28W T8EE/ELEE LOW PWR	22
2F28EEH	2L4’ 28WT8EE/ELEE HIGH PWR	64
2F28EEE	2L4’ 28W T8EE/ELEE	48
2F28EEL	2L4’ 28W T8EE/ELEE LOW PWR	42
3F28EEH	3L4’ 28W T8EE/ELEE HIGH PWR	96
3F28EEE	3L4’ 28W T8EE/ELEE	72
3F28EEL	3L4’ 28W T8EE/ELEE LOW PWR	63
4F28EEH	4L4’ 28W T8EE/ELEE HIGH PWR	126
Device Code	**Device Description**	**Rated Watts**
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
4F28EEE	4L4’ 28W T8EE/ELEE	94
4F28EEL	4L4’ 28W T8EE/ELEE LOW PWR	83
1F30EEH	1L4’ 30W T8EE/ELEE HIGH PWR	36
1F30EEE	1L4’ 30W T8EE/ELEE	26
1F30EEL	1L4’ 30W T8EE/ELEE LOW PWR	24
2F30EEH	2L4’ 30WT8EE/ELEE HIGH PWR	69
2F30EEE	2L4’ 30W T8EE/ELEE	52
2F30EEL	2L4’ 30W T8EE/ELEE LOW PWR	45
3F30EEH	3L4’ 30W T8EE/ELEE HIGH PWR	103
3F30EEE	3L4’ 30W T8EE/ELEE	77
3F30EEL	3L4’ 30W T8EE/ELEE LOW PWR	68
4F30EEH	4L4’ 30W T8EE/ELEE HIGH PWR	133
4F30EEE	4L4’ 30W T8EE/ELEE	101
4F30EEL	4L4’ 30W T8EE/ELEE LOW PWR	89
1F32EEH	1L4’ 32W T8EE/ELEE HIGH PWR	38
1F32EEE	1L4’ 32W T8EE/ELEE	28
1F32EEL	1L4’ 32W T8EE/ELEE LOW PWR	25
2F32EEH	2L4’ 32W T8EE/ELEE HIGH PWR	73
2F32EEE	2L4’ 32W T8EE/ELEE	53
2F32EEL	2L4’ 32W T8EE/ELEE LOW PWR	47
3F32EEH	3L4’ 32W T8EE/ELEE HIGH PWR	109
3F32EEE	3L4’ 32W T8EE/ELEE	82
3F32EEL	3L4’ 32W T8EE/ELEE LOW PWR	72
4F32EEH	4L4’ 32W T8EE/ELEE HIGH PWR	141
4F32EEE	4L4’ 32W T8EE/ELEE	107
4F32EEL	4L4’ 32W T8EE/ELEE LOW PWR	95
5F32EEH	5L4’ 32W T8EE/ELEE HIGH PWR	182
6F28EEE	6L4’ 28W T8EE/ELEE	144
6F28EEH	6L4’ 28W T8EE/ELEE HIGH PWR	192
6F28EEL	6L4’ 28W T8EE/ELEE LOW PWR	126
6F30EEE	6L4’ 30W T8EE/ELEE	154
Device Code	**Device Description**	**Rated Watts**
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
6F30EEL	6L4’ 30W T8EE/ELEE LOW PWR	136

6F32EEH	6L4’ 32W T8EE/ELEE HIGH PWR	218
6F32EEE	6L4’ 32W T8EE/ELEE	168
6F32EEL	6L4’ 32W T8EE/ELEE LOW PWR	146
7F32EEH	7L4’ 32W T8EE/ELEE HIGH PWR	250
Eight Foot T8 Systems		
1F59SSE	1L8’ T8/ELIG	60
1F80SSE	1L8’ T8 HO/ELIG	85
2F59SSE	2L8’ T8/ELIG	109
2F59SSL	2L8’ T8/ELIG LOW PWR	100
2F80SSE	2L8’ T8 HO/ELIG	160
Tandem Wired T8 High Efficient		
2W32EEE	2L4’ TW T8EE/ELIG	27
2W32EEL	2L4’ TW T8EE/ELEE LOW PWR	24
3W32EEE	3L4’ TW T8EE/ELIG	39
3W32EEL	3L4’ TW T8EE/ELEE LOW PWR	34
4W32EEE	4L4’ TW T8EE/ELIG	51
4W32EEL	4L4’ TW T8EE/ELEE LOW PWR	45
Tandem-Wired Fluorescent Systems		
2W32SSE	2L4’ TW T8/ELIG	30
2W32SSH	2L4’ TW T8/HI-LUM	39
2W40SEE	2L4’ TW EE/ELIG	30
2W40SSE	2L4’ TW STD/ELIG	36
2W59HSE	2L8’ TW T8 HO/ELIG	80
2W59SSE	2L8’ TW T8/ELIG	55
2W96HEE	2L8’ TW HO-EE/ELIG	85
2W96HSE	2L8’ TW HO-STD/ELIG	98
2W96SEE	2L8’ TW EE/ELIG	55
2W96SSE	2L8’ TW STD/ELIG	67
3W32SSE	3L4’ TW T8/ELIG	29
4D17SSE	4L2’ TW T8/ELIG	31
4D32EEE	4L4’ DTW T8EE/ELIG	51
4D32EEL	4L4’ DTW T8EE/ELEE LOW PWR	45
4D32SSE	4L4’ DTW T8/ELIG	53
4D32SSL	4L4 DTWT8/ELIG LOW POWER	49
4W32SSE	4L4’ TW T8/ELIG	27
4W32SSL	4L4 TWT8/ELIG LOW POWER	25
Device Code	**Device Description**	**Rated Watts**
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	4
1L005	5 WATT LED	5
1L006	6 WATT LED	6
1L007	7 WATT LED	7
1L008	8 WATT LED	8
1L009	9 WATT LED	9
1L010	10 WATT LED	10
1L011	11 WATT LED	11
1L012	12 WATT LED	12
1L013	13 WATT LED	13
1L014	14 WATT LED	14
1L015	15 WATT LED	15
1L016	16 WATT LED	16
1L017	17 WATT LED	17
1L018	18 WATT LED	18
1L019	19 WATT LED	19
1L020	20 WATT LED	20
1L021	21 WATT LED	21
1L022	22 WATT LED	22
1L023	23 WATT LED	23
1L024	24 WATT LED	24
1L025	25 WATT LED	25
1L026	26 WATT LED	26
1L027	27 WATT LED	27
1L028	28 WATT LED	28
1L029	29 WATT LED	29
1L030	30 WATT LED	30
1L031	31 WATT LED	31
1L032	32 WATT LED	32
1L033	33 WATT LED	33
1L034	34 WATT LED	34
1L035	35 WATT LED	35
1L036	36 WATT LED	36
1L037	37 WATT LED	37
1L038	38 WATT LED	38
1L039	39 WATT LED	39
1L040	40 WATT LED	40
1L041	41 WATT LED	41
1L042	42 WATT LED	42
Device Code	**Device Description**	**Rated Watts**
LED Lighting Fixtures		
1L043	43 WATT LED	43

1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46
1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L053	53 WATT LED	53
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L063	63 WATT LED	63
1L070	70 WATT LED	70
1L071	71 WATT LED	71
1L073	73 WATT LED	73
1L075	75 WATT LED	75
1L080	90 WATT LED	90
1L085	85 WATT LED	85
1L090	90 WATT LED	90
1L095	95 WATT LED	95
1L100	100 WATT LED	100
1L101	101 WATT LED	101
1L106	106 WATT LED	106
1L107	107 WATT LED	107
1L116	116 WATT LED	116
1L120	120 WATT LED	120
1L125	125 WATT LED	125
1L130	130 WATT LED	130
1L131	131 WATT LED	131

Device Code	**Device Description**	**Rated Watts**
LED Lighting Fixtures (cont.)		
1L135	135 WATT LED	135
1L139	139 WATT LED	139
1L140	140 WATT LED	140
1L145	145 WATT LED	145
1L150	150 WATT LED	150
1L155	155 WATT LED	155
1L160	160 WATT LED	160
1L164	164 WATT LED	164
1L165	165 WATT LED	165
1L170	170 WATT LED	170
1L175	175 WATT LED	175
1L180	180 WATT LED	180
1L185	185 WATT LED	185
1L186	186 WATT LED	186
1L190	190 WATT LED	190
1L200	200 WATT LED	200
1L204	204 WATT LED	204
1L205	205 WATT LED	205
1L210	210 WATT LED	210
1L211	211 WATT LED	211
1L220	220 WATT LED	220
1L233	233 WATT LED	233
1L235	235 WATT LED	235
1L237	237 WATT LED	237
1L240	240 WATT LED	240
1L256	256 WATT LED	256
1L279	279 WATT LED	279
1LED015	15 Watt LED	15

Table 5: Default Effective Lighting Hours by Building Type[4]

Building Type	Annual Operating Hours
College & University	4839
Grocery/Food Sales	5468
Hospital	5413
Industrial/Manufacturing	4988
K-12 School	2788
Lodging	4026
Medical Office	3673
Office Building	4181
Other	4336
Restaurant/Food Service	5018
Retail	4939
Warehouse & Storage	6512

[4] DNV GL (2018). *Lighting Hours of Use Study, Table 3-1.* Prepared for MA Program Administrators and EEAC.

Table 6: Cooling and Heating Equivalent Full Load Hours

Building (or Space) Type	Annual Cooling Hours ($Hours_{cool}$)	Cooling Full Load Hours ($EFLH_{cool}$)	Heating Full Load Hours ($EFLH_{heat}$)
Average – CLC	3,027	1,172	530
Average – NSTAR	3,027	1,172	N/A
Average – National Grid	2,539	935	984
Average – Unitil	1,896	755	1,329
Average – WMECO	1,896	755	1,329
Site Specific - NSTAR	800, 1000-6000 at 1000 hour increments	800, 1000-6000 at 1000 hour increments	N/A

- Average Cooling EFLHs from the 2010 NEEP HVAC Loadshape study.[5] 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.[6]
- Average Heating EFLHs derived from 2010 NEEP HVAC Loadshape study[7] and the Connecticut Program Savings Document for 2011 Program Year. [8]

[5] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.
[6] DNV GL (2014). *Memo – Develop Modified Runtime from NEEP HVAC Loadshape Study*. Prepared for National Grid and Northeast Utilities. August 20, 2014.
[7] Ibid.
[8] 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 7: Electric Non-Energy Impacts

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential Bulb	Lighting Quality and Lifetime		$3.00				
Residential Fixture	Lighting Quality and Lifetime		$3.50				
RNC Heating		$18.72					
RNC Heating	Thermal Comfort	$77.00					
RNC Heating	Noise Reduction	$40.00					
Residential Air Sealing		$19.28					
Residential Air Sealing	Thermal Comfort	$10.13					
Residential Air Sealing	Noise Reduction	$4.88					
Residential Air Sealing	Home Durability	$3.95					
Residential Air Sealing	Health Benefits	$0.32					
Residential Insulation		$47.31					
Residential Insulation	Thermal Comfort	$25.15					
Residential Insulation	Noise Reduction	$11.54					
Residential Insulation	Home Durability	$9.82					
Residential Insulation	Health Benefits	$0.80					
Residential Duct Sealing		$0.23					
Residential Duct Sealing	Thermal Comfort	$0.16					
Residential Duct Sealing	Home Durability	$0.06					
Residential Duct Sealing	Health Benefits	$0.01					
Residential Showerhead	Property Value Increase		$0.03				
Residential Thermostats		$3.63					
Residential Thermostats	Thermal Comfort	$3.99					
Residential Thermostats	Home Durability	$1.33					
Residential Thermostats	Health Benefits	$0.13					
Residential Refrigerator	Property Value Increase		$1.44				
Residential Furnace		$99.74					
Residential Furnace	Thermal Comfort	$36.35					
Residential Furnace	Home Durability	$11.53					
Residential Furnace	Equipment Maintenance	$50.69					
Residential Furnace	Health Benefits	$1.17					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential Boiler		$96.40					
Residential Boiler	Thermal Comfort	$35.77					
Residential Boiler	Home Durability	$11.25					
Residential Boiler	Equipment Maintenance	$48.23					
Residential Boiler	Health Benefits	$1.15					
Residential Water Heater Replacement		$0.70					
Residential Water Heater Replacement	Home Durability	$0.70					
Residential Combo Boiler		$75.52					
Residential Combo Boiler	Thermal Comfort	$32.12					
Residential Combo Boiler	Home Durability	$9.50					
Residential Combo Boiler	Home Durability	$32.87					
Residential Combo Boiler	Health Benefits	$1.03					
Residential MF Air Sealing		$19.35					
Residential MF Air Sealing	Thermal Comfort	$10.13					
Residential MF Air Sealing	Noise Reduction	$4.88					
Residential MF Air Sealing	Health Benefits	$0.32					
Residential MF Air Sealing	Rental Units Marketability	$0.07					
Residential MF Air Sealing	Reduced Tenant Complaints	$1.37					
Residential MF Air Sealing	Property Durability	$2.58					
Residential MF Insulation		$47.31					
Residential MF Insulation	Thermal Comfort	$25.15					
Residential MF Insulation	Noise Reduction	$11.54					
Residential MF Insulation	Home Durability	$9.82					
Residential MF Insulation	Health Benefits	$0.80					
Residential MF Showerhead		$0.58					
Residential MF Showerhead	Rental Units Marketability	$0.01					
Residential MF Showerhead	Reduced Tenant Complaints	$0.20					
Residential MF Showerhead	Property Durability	$0.37					
Residential MF Aerator		$0.58					
Residential MF Aerator	Rental Units Marketability	$0.01					
Residential MF Aerator	Reduced Tenant Complaints	$0.20					
Residential MF Aerator	Property Durability	$0.37					
Residential MF Thermostat		$14.35					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential MF Thermostat	Thermal Comfort	$3.99					
Residential MF Thermostat	Health Benefits	$0.13					
Residential MF Thermostat	Rental Unit Marketability	$0.11					
Residential MF Thermostat	Equipment Maintenance Reliability Due to Thermostats	$3.91					
Residential MF Thermostat	Property Durability	$4.05					
Residential MF Thermostat	Reduced Tenant Complaints	$2.16					
Residential MF Refrigerator		$20.10					
Residential MF Refrigerator	Rental Units Marketability	$0.34					
Residential MF Refrigerator	Reduced Tenant Complaints	$12.90					
Residential MF Refrigerator	Property Durability	$6.86					
Residential MF Common-Area Lighting		$91.00		$0.03			
Residential MF Common-Area Lighting	O&M	$91.00		$0.03			
Residential MF Heat Pump		$5.70		$-			
Residential MF Heat Pump	Noise Reduction	$2.50					
Residential MF Heat Pump	Home Durability	$1.17					
Residential MF Heat Pump	Thermal Comfort	$1.96					
Residential MF Heat Pump	Health Benefits	$0.07					
Residential MF DMSHP		$5.98		$-			
Residential MF DMSHP	Noise Reduction	$1.41					
Residential MF DMSHP	Home Durability	$1.96					
Residential MF DMSHP	Thermal Comfort	$2.53					
Residential MF DMSHP	Health Benefits	$0.08					
Residential Retail Thermostats		$4.19					
Thermostats	Thermal Comfort	$3.99					
Thermostats	Home Durability	$1.33					
Thermostats	Health Benefits	$0.13					
Residential Retail Air Conditioner		$8.98					
Air Conditioners	Thermal Comfort						
Air Conditioners	Noise Reduction						
Air Conditioners	Home Durability						
Air Conditioners	Equipment Maintenance						
Air Conditioners	Health Benefits						

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential Retail Heat Pump		$8.11					
Heat Pumps	Thermal Comfort						
Heat Pumps	Home Durability						
Heat Pumps	Equipment Maintenance						
Heat Pumps	Health Benefits						
Residential Retail Ductless Mini Split Heat Pump		$4.21					
Ductless Mini Split Heat Pumps	Thermal Comfort						
Ductless Mini Split Heat Pumps	Home Durability						
Ductless Mini Split Heat Pumps	Equipment Maintenance						
Ductless Mini Split Heat Pumps	Health Benefits						
Residential Retail Duct Sealing		$0.23					
Residential Retail Down size 1/2 ton		$0.64					
Down size 1/2 ton	Thermal Comfort	$0.19					
Down size 1/2 ton	Home Durability	$0.07					
Down size 1/2 ton	Equipment Maintenance	$0.37					
Down size 1/2 ton	Health Benefits	$0.01					
Residential Retail Digital Check up/tune up		$1.53					
Digital Check up/tune up	Thermal Comfort	$0.47					
Digital Check up/tune up	Home Durability	$0.18					
Digital Check up/tune up	Equipment Maintenance	$0.87					
Digital Check up/tune up	Health Benefits	$0.01					
Residential Retail QIV		$1.53					
QIV	Thermal Comfort	$0.47					
QIV	Home Durability	$0.18					
QIV	Equipment Maintenance	$0.87					
QIV	Health Benefits	$0.01					
IE Rate-Discount-Only NEI		$-	$-	$0.05	$0.01	$-	$-
IE Rate-Discount-Only NEI	Rate Discounts			$0.05			
IE Rate-Discount-Only NEI	Price Hedging				$0.01		
IE SF Participant NEI		$10.37	$56.00	$0.05	$0.01	$-	$-
IE SF Participant NEI	Arrearages	$2.61					
IE SF Participant NEI	Bad Debt Write-offs	$3.74					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE SF Participant NEI	Terminations and Reconnections	$0.43					
IE SF Participant NEI	Customer Calls and Collections	$0.58					
IE SF Participant NEI	Notices	$0.34					
IE SF Participant NEI	Improved Safety	$2.67					
IE SF Participant NEI	Lighting Quality and Lifetime		$56.00				
IE SF Participant NEI	Rate Discounts			$0.05			
IE SF Participant NEI	Price Hedging				$0.01		
IE SF Weatherization		$558.21	$-	$0.05	$0.01	$-	$-
IE SF Weatherization	Thermal Comfort	$66.02					
IE SF Weatherization	Noise Reduction	$29.95					
IE SF Weatherization	Home Durability	$19.37					
IE SF Weatherization	Health Benefits	$423.23					
IE SF Weatherization	Improved Safety	$19.64					
IE SF Weatherization	Rate Discounts			$0.05			
IE SF Weatherization	Price Hedging				$0.01		
IE SF Air Sealing		$295.21	$-	$0.05	$0.01	$-	$-
IE SF Air Sealing	Thermal Comfort	$35.89					
IE SF Air Sealing	Noise Reduction	$16.39					
IE SF Air Sealing	Home Durability	$10.61					
IE SF Air Sealing	Health Benefits	$230.08					
IE SF Air Sealing	Improved Safety	$2.24					
IE SF Air Sealing	Rate Discounts			$0.05			
IE SF Air Sealing	Price Hedging				$0.01		
IE SF Insulation		$263.00	$-	$0.05	$0.01	$-	$-
IE SF Insulation	Thermal Comfort	$30.13					
IE SF Insulation	Noise Reduction	$13.56					
IE SF Insulation	Home Durability	$8.76					
IE SF Insulation	Health Benefits	$193.15					
IE SF Insulation	Improved Safety	$17.40					
IE SF Insulation	Rate Discounts			$0.05			
IE SF Insulation	Price Hedging				$0.01		
IE SF Heating System Retrofit		$310.82	$-	$0.05	$0.01	$-	$-
IE SF Heating System Retrofit	Safety Related Emergency Calls	$8.43					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE SF Heating System Retrofit	Thermal Comfort	$33.24					
IE SF Heating System Retrofit	Equipment Maintenance	$9.72					
IE SF Heating System Retrofit	Home Durability	$27.43					
IE SF Heating System Retrofit	Health Benefits	$213.13					
IE SF Heating System Retrofit	Improved Safety	$18.87					
IE SF Heating System Retrofit	Rate Discounts			$0.05			
IE SF Heating System Retrofit	Price Hedging	$-			$0.01		
IE SF Heat Pump		$310.82	$-	$0.05	$0.01	$-	$-
IE SF Heat Pump	Home Durability	$9.72					
IE SF Heat Pump	Thermal Comfort	$33.24					
IE SF Heat Pump	Health Benefits	$213.13					
IE SF Heat Pump	Equipment Maintenance	$27.43					
IE SF Heat Pump	Improved Safety	$18.87					
IE SF Heat Pump	Safety Related Emergency Calls	$8.43					
IE SF Heat Pump	Rate Discounts			$0.05			
IE SF Heat Pump	Price Hedging	$0.00			$0.01		
IE SF HP Water Heater		$4.64	$0.00	$0.05	$0.01	$0.00	$0.00
IE SF HP Water Heater	Home Durability	$0.20					
IE SF HP Water Heater	Improved Safety	$4.44					
IE SF HP Water Heater	Rate Discounts			$0.05			
IE SF HP Water Heater	Price Hedging				$0.01		
IE SF Duct Sealing		$6.21	$0.00	$0.05	$0.01	$0.00	$0.00
IE SF Duct Sealing	Thermal Comfort	$0.81					
IE SF Duct Sealing	Home Durability	$0.23					
IE SF Duct Sealing	Health Benefits	$5.17					
IE SF Duct Sealing	Rate Discounts			$0.05			
IE SF Duct Sealing	Price Hedging				$0.01		
IE SF Pipe Wrap		$48.94	$0.00	$0.05	$0.01		
IE SF Pipe Wrap	Thermal Comfort	$6.60					
IE SF Pipe Wrap	Health Benefits	$42.34					
IE SF Pipe Wrap	Rate Discounts			$0.05			
IE SF Pipe Wrap	Price Hedging				$0.01		
IE SF Showerhead		$0.00	$1.72	$0.05	$0.01	$0.00	$0.00
IE SF Showerhead	Property Value Increase		$1.72				

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE SF Showerhead	Rate Discounts			$0.05			
IE SF Showerhead	Price Hedging				$0.01		
IE SF Replacement Freezer		$1.40	$26.61	$0.05	$0.01	$0.00	$0.00
IE SF Replacement Freezer	Improved Safety	$1.40					
IE SF Replacement Freezer	Rate Discounts			$0.05			
IE SF Replacement Freezer	Property Value Increase		$26.61				
IE SF Replacement Freezer	Price Hedging				$0.01		
IE SF Refrigerator		$1.40	$26.61	$0.05	$0.01	$0.00	$0.00
IE SF Refrigerator	Improved Safety	$1.40					
IE SF Refrigerator	Rate Discounts			$0.05			
IE SF Refrigerator	Property Value Increase		$26.61				
IE SF Refrigerator	Price Hedging				$0.01		
IE SF Thermostat		$44.53	$0.00	$0.05	$0.01		
IE SF Thermostat	Thermal Comfort	$5.78					
IE SF Thermostat	Home Durability	$1.68					
IE SF Thermostat	Health Benefits	$37.07					
IE SF Thermostat	Rate Discounts			$0.05			
IE SF Thermostat	Price Hedging				$0.01		
IE SF Window AC Replacement		$49.50	$0.00	$0.05	$0.01	$0.00	$0.00
IE SF Window AC Replacement	Window Air Conditioner Replacement	$49.50					
IE SF Window AC Replacement	Rate Discounts			$0.05			
IE SF Window AC Replacement	Price Hedging				$0.01		
IE MF Participant NEI		$7.70	$56.00	$0.05	$0.01	$0.00	$0.00
IE MF Participant NEI	Arrearages	$2.61					
IE MF Participant NEI	Bad Debt Write-offs	$3.74					
IE MF Participant NEI	Terminations and Reconnections	$0.43					
IE MF Participant NEI	Customer Calls and Collections	$0.58					
IE MF Participant NEI	Notices	$0.34					
IE MF Participant NEI	Lighting Quality and Lifetime		$56.00				
IE MF Participant NEI	Rate Discounts			$0.05			
IE MF Participant NEI	Price Hedging				$0.01		
IE MF Weatherization		$97.82	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Weatherization	Thermal Comfort	$7.57					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Weatherization	Noise Reduction	$29.95					
IE MF Weatherization	Health Benefits	$56.28					
IE MF Weatherization	Property Durability	$2.58					
IE MF Weatherization	Rental Units Marketability	$0.07					
IE MF Weatherization	Reduced Tenant Complaints	$1.37					
IE MF Weatherization	Rate Discounts			$0.05			
IE MF Weatherization	Price Hedging				$0.01		
IE MF Air Sealing		$60.01	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Air Sealing	Thermal Comfort	$3.40					
IE MF Air Sealing	Noise Reduction	$16.39					
IE MF Air Sealing	Home Durability	$10.61					
IE MF Air Sealing	Health Benefits	$25.28					
IE MF Air Sealing	Improved Safety	$0.31					
IE MF Air Sealing	Property Durability	$2.58					
IE MF Air Sealing	Rental Units Marketability	$0.07					
IE MF Air Sealing	Reduced Tenant Complaints	$1.37					
IE MF Air Sealing	Rate Discounts			$0.05			
IE MF Air Sealing	Price Hedging				$0.01		
IE MF Insulation		$60.09	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Insulation	Thermal Comfort	$4.17					
IE MF Insulation	Noise Reduction	$13.56					
IE MF Insulation	Home Durability	$8.76					
IE MF Insulation	Health Benefits	$31.00					
IE MF Insulation	Improved Safety	$2.60					
IE MF Insulation	Rate Discounts			$0.05			
IE MF Insulation	Price Hedging				$0.01		
IE MF Heating System Retrofit		$77.93	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Heating System Retrofit	Thermal Comfort	$4.55					
IE MF Heating System Retrofit	Equipment Maintenance	$9.72					
IE MF Heating System Retrofit	Home Durability	$27.43					
IE MF Heating System Retrofit	Health Benefits	$33.83					
IE MF Heating System Retrofit	Improved Safety	$2.40					
IE MF Heating System Retrofit	Rate Discounts			$0.05			
IE MF Heating System Retrofit	Price Hedging	$0.00			$0.01		

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Heat Pump		$123.91	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Heat Pump	Home Durability	$9.72					
IE MF Heat Pump	Thermal Comfort	$28.01					
IE MF Heat Pump	Health Benefits	$5.27					
IE MF Heat Pump	Equipment Maintenance	$27.43					
IE MF Heat Pump	Improved Safety	$45.05					
IE MF Heat Pump	Safety Related Emergency Calls	$8.43					
IE MF Heat Pump	Rate Discounts			$0.05			
IE MF Heat Pump	Price Hedging	$0.00			$0.01		
IE MF Duct Sealing		$1.04	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Duct Sealing	Thermal Comfort	$0.68					
IE MF Duct Sealing	Home Durability	$0.23					
IE MF Duct Sealing	Health Benefits	$0.13					
IE MF Duct Sealing	Rate Discounts			$0.05			
IE MF Duct Sealing	Price Hedging				$0.01		
IE MF Pipe Wrap		$6.61	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Pipe Wrap	Thermal Comfort	$5.56					
IE MF Pipe Wrap	Health Benefits	$1.05					
IE MF Pipe Wrap	Rate Discounts			$0.05			
IE MF Pipe Wrap	Price Hedging				$0.01		
IE MF Water Heater		$0.58	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Water Heater	Rate Discounts			$0.05			
IE MF Water Heater	Price Hedging				$0.01		
IE MF Water Heater	Rental Units Marketability	$0.01					
IE MF Water Heater	Property Durability	$0.37					
IE MF Water Heater	Reduced Tenant Complaints	$0.20					
IE MF Showerhead		$0.58	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Showerhead	Rate Discounts			$0.05			
IE MF Showerhead	Price Hedging				$0.01		
IE MF Showerhead	Rental Units Marketability	$0.01					
IE MF Showerhead	Home Durability	$0.37					
IE MF Showerhead	Reduced Tenant Complaints	$0.20					
IE MF Aerator		$0.58	$0.00	$0.05	$0.01	$0.00	$0.00

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Aerator	Rate Discounts			$0.05			
IE MF Aerator	Price Hedging				$0.01		
IE MF Aerator	Rental Units Marketability	$0.01					
IE MF Aerator	Home Durability	$0.37					
IE MF Aerator	Reduced Tenant Complaints	$0.20					
IE MF Thermostat		$16.02	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Thermostat	Thermal Comfort	$4.87					
IE MF Thermostat	Health Benefits	$0.92					
IE MF Thermostat	Rental Unit Marketability	$0.11					
IE MF Thermostat	Equipment Maintenance Reliability Due to Thermostats	$3.91					
IE MF Thermostat	Property Durability	$4.05					
IE MF Thermostat	Reduced Tenant Complaints	$2.16					
IE MF Thermostat	Rate Discounts			$0.05			
IE MF Thermostat	Price Hedging				$0.01		
IE MF Common Area Lighting		$109.20	$0.00	$0.08	$0.01	$0.00	$0.00
IE MF Common Area Lighting	Rate Discounts			$0.05			
IE MF Common Area Lighting	Price Hedging				$0.01		
IE MF Common Area Lighting	Lighting Quality and Lifetime	$109.20		$0.03			
IE MF Freezer		$20.10	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Freezer	Rental Units Marketability	$0.34					
IE MF Freezer	Property Durability	$12.90					
IE MF Freezer	Reduced Tenant Complaints	$6.86					
IE MF Freezer	Rate Discounts			$0.05			
IE MF Freezer	Price Hedging				$0.01		
IE MF Refrigerator		$20.10	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Refrigerator	Rental Units Marketability	$0.34					
IE MF Refrigerator	Property Durability	$12.90					
IE MF Refrigerator	Reduced Tenant Complaints	$6.86					
IE MF Refrigerator	Rate Discounts			$0.05			
IE MF Refrigerator	Price Hedging				$0.01		
IE MF Window AC Replacement		$49.50	$0.00	$0.05	$0.01	$0.00	$0.00
IE MF Window AC Replacement	Window Air Conditioner Replacement	$49.50					
IE MF Window AC Replacement	Rate Discounts			$0.05			

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Window AC Replacement	Price Hedging				$0.01		
C&I NC Compressed Air - Custom	O&M			$0.03			
C&I NC Compressed Air - Prescriptive	O&M			$0.04			
C&I NC HVAC - Custom	O&M			$0.00			
C&I NC Lighting - Custom	O&M			$0.00			
C&I NC Lighting - Prescriptive	O&M			$0.02			
C&I NC Process - Custom	O&M			$0.01			
C&I NC Refrigeration - Custom	O&M			$0.01			
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			
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			
C&I Retro HVAC - Prescriptive	Administrative costs, other costs, other labor costs, O&M, rent revenue			$0.10			
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			
C&I Retro Lighting - Prescriptive	Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal			$0.03			
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			
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			
C&I Retro Refrigeration - Prescriptive	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent			$0.05			

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
	revenue, sales revenue, waste disposal						
CHP Systems	Administrative costs, O&M			-$0.01			

Table 2: Gas Non-Energy Impacts

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential Light Bulb	Lighting Quality and Lifetime		$3.00				
Residential Fixtures	Lighting Quality and Lifetime		$3.50				
Residential NC Heating		$117.00					
Residential NC Heating	Thermal Comfort	$77.00					
Residential NC Heating	Noise Reduction	$40.00					
Residential NC Heating (High Rise)		$5.85					
Residential NC Heating (High Rise)	Thermal Comfort	$77.00					
Residential NC Heating (High Rise)	Noise Reduction	$40.00					
Residential Insulation		$47.31	$0.00				
Residential Insulation	Thermal Comfort	$25.15					
Residential Insulation	Noise Reduction	$11.54					
Residential Insulation	Home Durability	$9.82					
Residential Insulation	Health Benefits	$0.80					
Residential Air Sealing		$19.28	$0.00				
Residential Air Sealing	Thermal Comfort	$10.13					
Residential Air Sealing	Noise Reduction	$4.88					
Residential Air Sealing	Home Durability	$3.95					
Residential Air Sealing	Health Benefits	$0.32					
Residential MF Air Sealing		$19.35	$0.00				
Residential MF Air Sealing	Thermal Comfort	$10.13					
Residential MF Air Sealing	Noise Reduction	$4.88					
Residential MF Air Sealing	Health Benefits	$0.32					
Residential MF Air Sealing	Rental Units Marketability	$0.07					
Residential MF Air Sealing	Reduced Tenant Complaints	$1.37					
Residential MF Air Sealing	Property Durability	$2.58					
Residential Duct Sealing		$0.23	$0.00				
Residential Duct Sealing	Thermal Comfort	$0.16					
Residential Duct Sealing	Home Durability	$0.06					
Residential Duct Sealing	Health Benefits	$0.01					
Residential Low-Flow Showerhead	Property Value Increase	$0.00	$0.03				

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential MF Low-Flow Showerhead/Aerator		$0.58	$0.00				
Residential MF Low-Flow Showerhead/Aerator	Rental Units Marketability	$0.01					
Residential MF Low-Flow Showerhead/Aerator	Reduced Tenant Complaints	$0.20					
Residential MF Low-Flow Showerhead/Aerator	Property Durability	$0.37					
Residential Installed - Thermostat (per house receiving tstat)		$3.63	$0.00				
Residential Installed - Thermostat (per house receiving tstat)	Thermal Comfort	$3.99					
Residential Installed - Thermostat (per house receiving tstat)	Home Durability	$1.33					
Residential Installed - Thermostat (per house receiving tstat)	Health Benefits	$0.13					
Residential DHW - Condensing/Indirect		$0.70	$0.00				
Residential DHW - Condensing/Indirect	Home Durability	$0.70					
Residential DHW - Tankless		$1.23	$0.00				
Residential DHW - Tankless	Home Durability	$1.23					
Residential DHW - Stand Alone		$1.30	$0.00				
Residential DHW - Stand Alone	Home Durability	$1.30					
Residential Combo Condensing Boiler		$75.52	*$0.00*				
Residential Combo Condensing Boiler	Thermal Comfort	$32.12					
Residential Combo Condensing Boiler	Home Durability	$9.50					
Residential Combo Condensing Boiler	Equipment Maintenance	$32.87					
Residential Combo Condensing Boiler	Health Benefits	$1.03					
Residential Combo Condensing Furnace		$30.84					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential Combo Condensing Furnace	Thermal Comfort	$24.32					
Residential Combo Condensing Furnace	Home Durability	$5.75					
Residential Combo Condensing Furnace	Health Benefits	$0.78					
Residential Furnace		$92.07	$0.00				
Residential Furnace	Thermal Comfort	$35.01					
Residential Furnace	Home Durability	$10.88					
Residential Furnace	Equipment Maintenance	$45.06					
Residential Furnace	Health Benefits	$1.12					
Residential Boiler		$80.94	$0.00				
Residential Boiler	Thermal Comfort	$33.07					
Residential Boiler	Home Durability	$9.95					
Residential Boiler	Equipment Maintenance	$36.86					
Residential Boiler	Health Benefits	$1.06					
Residential Retail - Thermostat (per house receiving tstat)		$4.19	$0.00				
Residential Retail - Thermostat (per house receiving tstat)	Thermal Comfort	$3.99					
Residential Retail - Thermostat (per house receiving tstat)	Home Durability	$1.33					
Residential Retail - Thermostat (per house receiving tstat)	Health Benefits	$0.13					
Residential - MF Thermostat (per house receiving tstat)		$11.96	$0.00				
Residential - MF Thermostat (per house receiving tstat)	Thermal Comfort	$3.99					
Residential - MF Thermostat (per house receiving tstat)	Health Benefits	$0.13					
Residential - MF Thermostat (per house receiving tstat)	Rental Unit Marketability	$0.11					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
Residential - MF Thermostat (per house receiving tstat)	Equipment Maintenance Reliability Due to Thermostats	$3.91					
Residential - MF Thermostat (per house receiving tstat)	Property Durability	$4.05					
Residential - MF Thermostat (per house receiving tstat)	Reduced Tenant Complaints	$2.16					
Common Area Lighting		$26.41		$0.03			
Common Area Lighting	O&M			$0.03			
Common Area Lighting	Rental Units Marketability	$0.44					
Common Area Lighting	Property Durability	$16.95					
Common Area Lighting	Reduced Tenant Complaints	$9.02					
IE Rate-Discount-Only NEI		$0.00	$0.00	$0.00	$0.00	$0.16	$0.08
IE Rate-Discount-Only NEI	Rate Discounts					$0.16	
IE Rate-Discount-Only NEI	Price Hedging						$0.08
IE Participant		$7.70	$0.00	$0.00	$0.00	$0.00	$0.00
IE Participant	Arrearages	$2.61					
IE Participant	Bad-Debt Write-off	$3.74					
IE Participant	Terminations & Reconnections	$0.43					
IE Participant	Customer Calls & Collections	$0.58					
IE Participant	Notices	$0.34					
IE SF Weatherization		$558.21	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Weatherization	Rate Discounts					$0.16	
IE SF Weatherization	Thermal Comfort	$66.02					
IE SF Weatherization	Noise Reduction	$29.95					
IE SF Weatherization	Home Durability	$19.37					
IE SF Weatherization	Health Benefits	$423.23					
IE SF Weatherization	Improved Safety	$19.64					
IE SF Weatherization	Price Hedging						$0.08
IE SF Air Sealing		$295.21	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Air Sealing	Rate Discounts					$0.16	

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE SF Air Sealing	Thermal Comfort	$35.89					
IE SF Air Sealing	Noise Reduction	$16.39					
IE SF Air Sealing	Home Durability	$10.61					
IE SF Air Sealing	Health Benefits	$230.08					
IE SF Air Sealing	Improved Safety	$2.24					
IE SF Air Sealing	Price Hedging						$0.08
IE SF Insulation		$263.00	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Insulation	Rate Discounts					$0.16	
IE SF Insulation	Thermal Comfort	$30.13					
IE SF Insulation	Noise Reduction	$13.56					
IE SF Insulation	Home Durability	$8.76					
IE SF Insulation	Health Benefits	$193.15					
IE SF Insulation	Improved Safety	$17.40					
IE SF Insulation	Price Hedging						$0.08
IE SF Heating System Replacement		$310.82	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Heating System Replacement	Rate Discounts					$0.16	
IE SF Heating System Replacement	Safety Related Emergency Calls	$8.43					
IE SF Heating System Replacement	Thermal Comfort	$33.24					
IE SF Heating System Replacement	Equipment Maintenance	$9.72					
IE SF Heating System Replacement	Home Durability	$27.43					
IE SF Heating System Replacement	Health Benefits	$213.13					
IE SF Heating System Replacement	Improved Safety	$18.87					
IE SF Heating System Replacement	Price Hedging				$0.00		$0.08
IE SF Low-Flow Showerhead		$0.00	$1.72	$0.00	$0.00	$0.16	$0.08
IE SF Low-Flow Showerhead	Property Value Increase		$1.72				

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE SF Low-Flow Showerhead	Rate Discounts					$0.16	
IE SF Low-Flow Showerhead	Price Hedging						$0.08
IE SF Aerator		$0.00	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Aerator	Rate Discounts					$0.16	
IE SF Aerator	Price Hedging						$0.08
IE SF Duct Insulation		$0.00	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Duct Insulation	Rate Discounts					$0.16	
IE SF Duct Insulation	Price Hedging						$0.08
IE SF Duct Sealing		$6.21	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Duct Sealing	Rate Discounts					$0.16	
IE SF Duct Sealing	Thermal Comfort	$0.81					
IE SF Duct Sealing	Home Durability	$0.23					
IE SF Duct Sealing	Health Benefits	$5.17					
IE Duct Sealing	Price Hedging						$0.08
IE SF Pipe Wrap		$48.94	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Pipe Wrap	Rate Discounts					$0.16	
IE SF Pipe Wrap	Thermal Comfort	$6.60					
IE SF Pipe Wrap	Health Benefits	$42.34					
IE SF Pipe Wrap	Price Hedging						$0.08
IE SF Thermostat		$44.53	$0.00	$0.00	$0.00	$0.16	$0.08
IE SF Thermostat	Rate Discounts					$0.16	
IE SF Thermostat	Thermal Comfort	$5.78					
IE SF Thermostat	Home Durability	$1.68					
IE SF Thermostat	Health Benefits	$37.07					
IE SF Thermostat	Price Hedging						$0.08
IE MF Air Sealing		$49.40	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Air Sealing	Rate Discounts					$0.16	
IE MF Air Sealing	Thermal Comfort	$3.40					
IE MF Air Sealing	Noise Reduction	$16.39					
IE MF Air Sealing	Health Benefits	$25.28					
IE MF Air Sealing	Improved Safety	$0.31					
IE MF Air Sealing	Property Durability	$2.58					
IE MF Air Sealing	Rental Units Marketability	$0.07					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Air Sealing	Reduced Tenant Complaints	$1.37					
IE MF Air Sealing	Price Hedging	$0.00					$0.08
IE MF Insulation		$60.09	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Insulation	Rate Discounts					$0.16	
IE MF Insulation	Thermal Comfort	$4.17					
IE MF Insulation	Noise Reduction	$13.56					
IE MF Insulation	Health Benefits	$31.00					
IE MF Air Sealing	Improved Safety	$2.60					
IE MF Insulation	Property Durability	$8.76					
IE MF Insulation	Price Hedging						$0.08
IE MF Duct Sealing		$1.04	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Duct Sealing	Rate Discounts					$0.16	
IE MF Duct Sealing	Thermal Comfort	$0.68					
IE MF Duct Sealing	Property Durability	$0.23					
IE MF Duct Sealing	Health Benefits	$0.13					
IE MF Duct Sealing	Price Hedging				$0.00		$0.08
IE MF Duct Insulation		*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.16*	*$0.08*
IE MF Duct Insulation	Rate Discounts					$0.16	
IE MF Duct Insulation	Price Hedging						$0.08
IE MF Pipe Wrap		$6.61	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Pipe Wrap	Rate Discounts					$0.16	
IE MF Pipe Wrap	Thermal Comfort	$5.56					
IE MF Pipe Wrap	Health Benefits	$1.05					
IE MF Pipe Wrap	Price Hedging				$0.00		$0.08
IE MF Heating System Retrofit		$86.36	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Heating System Retrofit	Rate Discounts					$0.16	
IE MF Heating System Retrofit	Safety Related Emergency Calls	$8.43					
IE MF Heating System Retrofit	Thermal Comfort	$4.55					
IE MF Heating System Retrofit	Property Durability	$9.72					
IE MF Heating System Retrofit	Equipment Maintenance	$27.43					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Heating System Retrofit	Health Benefits	$33.83					
IE MF Heating System Retrofit	Improved Safety	$2.40					
IE MF Heating System Retrofit	Price Hedging						$0.08
IE MF Water Heater		$0.58	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Water Heater	Rate Discounts					$0.16	
IE MF Water Heater	Rental Units Marketability	$0.01					
IE MF Water Heater	Reduced Tenant Complaints	$0.20					
IE MF Water Heater	Property Durability	$0.37					
IE MF Water Heater	Price Hedging						$0.08
IE MF Low-Flow Showerhead		$0.58	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Low-Flow Showerhead	Rate Discounts					$0.16	
IE MF Low-Flow Showerhead	Rental Units Marketability	$0.01					
IE MF Low-Flow Showerhead	Property Durability	$0.37					
IE MF Low-Flow Showerhead	Reduced Tenant Complaints	$0.20					
IE MF Low-Flow Showerhead	Price Hedging				$0.00		$0.08
IE MF Aerator		$0.58	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Aerator	Rate Discounts					$0.16	
IE MF Aerator	Rental Units Marketability	$0.01					
IE MF Aerator	Property Durability	$0.37					
IE MF Aerator	Reduced Tenant Complaints	$0.20					
IE MF Aerator	Price Hedging				$0.00		$0.08
IE MF Thermostat		$16.02	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Thermostat	Rate Discounts					$0.16	
IE MF Thermostat	Thermal Comfort	$4.87					
IE MF Thermostat	Health Benefits	$0.92					
IE MF Thermostat	Rental Unit Marketability	$0.11					

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
IE MF Thermostat	Equipment Maintenance Reliability Due to Thermostats	$3.91					
IE MF Thermostat	Property Durability	$4.05					
IE MF Thermostat	Reduced Tenant Complaints	$2.16					
IE MF Thermostat	Price Hedging						$0.08
IE MF Custom		$0.00	$0.00	$0.00	$0.00	$0.16	$0.08
IE MF Custom	Rate Discounts					$0.16	
IE MF Custom	Price Hedging						$0.08
C&I - New Bldg - Custom - Comprehensive Design	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$0.00	
C&I - New Bldg - Custom - Commercial Kitchen	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$3.40	
C&I - New Bldg - Custom - Boilers	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					-$0.01	
C&I - New Bldg - Custom - Other	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					-$0.03	
C&I - New Bldg - Prescriptive - HVAC/Heat Recovery	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$0.24	
C&I - New Bldg - Prescriptive - Other Gas Heating	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$0.05	

Measure Type	NEI Category	Annual per Unit	One time per Unit	Annual per kWh	One time per KWh	Annual per Therm	One time per Therm
C&I - New Bldg - Prescriptive - Boilers	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					-$0.08	
C&I - New Bldg - Prescriptive - Commercial Kitchen	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$3.40	
C&I - Existing - Prescriptive - HVAC	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$1.35	
C&I - Existing - Prescriptive - Building Envelope	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$3.62	
C&I - Existing - Custom - HVAC	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$0.23	
C&I - Existing - Custom - Building Envelope	Admin costs, material movement, other costs, other labor, O&M, product spoilage, waste disposal					$0.48	
C&I Lighting - Prescriptive	Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal			$0.03			
C&I Lighting - Custom	Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal			$0.06			

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	Kilo-Watt, a unit of electric demand equal to 1,000 watts
kWh	Kilowatt-Hour, a unit of energy (1 kilowatt of power supplied for one hour)
LED	Light-Emitting Diode (one type of solid-state lighting)
LCD	Liquid Crystal Display (a technology used for computer monitors and similar displays)
MMBtu	One million British Thermal Units (see “Btu” in the Glossary)
MW	Megawatt – a measure of electric demand equal to 1,000 kilowatts
MWh	Megawatt-hour – a measure of energy equal to 1,000 kilowatt-hours
NEB	Non-Electric Benefit (see the Glossary)
NEI	Non-Energy Impact
NE-ISO	New England Independent System Operator
NTG	Net-to-Gross (see the Glossary)
O&M	Operations and Maintenance
PA	Program Administrator (see the Glossary)
PARIS	Planning And Reporting Information System (a DOER database - see the Glossary)
PC	Personal Computer
RR	Realization Rate (see the Glossary)
SEER	Seasonal Energy Efficiency Ratio (see the Glossary)
SO	Spillover (see the Glossary)
SPF	Savings Persistence Factor (see the Glossary)
SSL	Solid-State Lighting (e.g., LED lighting)
VSD	Variable-Speed Drive

Appendix 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.

TERM	DESCRIPTION
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 PARIS codes include: ALght Lighting HVAC HVAC CMoDr Motors & Drives DRefr Refrigeration EHoWa Hot Water FComA Compressed Air GProc Process* HEUBe Behavior Ienvl Insulation & Air Sealing JGchp Combined Heat & Power KSdhw Solar Hot Water LDmdR Demand Response MPvEl Photovoltaic Panels *For residential measures, "process" is used for products that have low savings, such as consumer electronics, or do not conform to existing end use categories. For commercial and industrial measures, "process" is used for systematic improvements to manufacturing or pump systems, or efficient models of specialty equipment not covered in other end uses.
Energy Efficiency Ratio (EER)	The Energy Efficiency Ratio is a measure of the efficiency of a cooling system at a specified peak, design temperature, or outdoor temperature. In technical terms, EER is the steady-state rate of heat energy removal (i.e. cooling capacity) of a product measured in Btuh output divided by watts input.
ENERGY STAR® (ES)	Brand name for the voluntary energy efficiency labeling initiative sponsored by the U.S. Environmental Protection Agency.
Energy Costing Period	A period of relatively high or low system energy cost, by season. The energy periods defined by ISO-NE are: • **Summer Peak**: 6am–10pm, Monday–Friday (except ISO holidays), June–September • **Summer Off-Peak:** Summer hours not included in the summer peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, June–September • **Winter Peak:** 6am–10pm, Monday–Friday (except ISO holidays), January–May and October–December • **Winter Off-Peak:** Winter hours not included in the sinter peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, January–May and October–December.
Equivalent Full Load Hours (EFLH)	The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).
Free Rider	A customer who participates in an energy efficiency program, but would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available.
Free-Ridership Rate	The percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.
Gross kW	Expected demand reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.

TERM	DESCRIPTION
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

TERM	DESCRIPTION
Operating Hours	Hours that a piece of equipment is expected to be in operation, not necessarily at full load (typically expressed per year).
PARIS	Planning And Reporting Information System, a statewide database maintained by the Department of Energy Resources (DOER) that emulates the program administrators' screening model. As a repository for quantitative data from plans, preliminary reports, and reports, PARIS generates information that includes funding sources, customer profiles, program participation, costs, savings, cost-effectiveness and program impact factors from evaluation studies. DOER developed PARIS in 2003 as a collaborative effort with the Department of Public Utilities and the electric program administrators. Beginning with the 2010 plans, PARIS holds data from gas program administrators.
Participant	A customer who installs a measure through regular program channels and receives any benefit (i.e. incentive) that is available through the program because of their participation. Free-riders are a subset of this group.
Prescriptive Measure	A prescriptive measure is generally offered by use of a prescriptive form with a prescribed incentive based on the parameters of the efficient equipment or practice.
Program Administrator (PA)	Those entities that oversee public benefit funds in the implementation of energy efficiency programs. This generally includes regulated utilities, other organizations chosen to implement such programs, and state energy offices. The Massachusetts electric PAs include Cape Light Compact, National Grid, NSTAR, Western Massachusetts Electric Company (WMECo), and Unitil. The Massachusetts natural gas PAs include Bay State Gas, Berkshire Gas, and New England Gas.
Realization Rate (RR)	The ratio of measure savings developed from impact evaluations to the estimated measure savings derived from the TRM savings algorithms. This factor is used to adjust the estimated savings when significant justification for such adjustment exists. The components of the realization rate are described in detail in the section on Impact Factors.
Retrofit	The replacement of a piece of equipment or device before the end of its useful or planned life for the purpose of achieving energy savings. "Retrofit" measures are sometimes referred to as "early retirement" when the removal of the old equipment is aggressively pursued.
Savings Persistence Factor (SPF)	Percentage of first-year energy or demand savings expected to persist over the life of the installed energy efficiency equipment. The SPF is developed by conducting surveys of installed equipment several years after installation to determine the operational capability of the equipment. In contrast, *measure persistence* takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor.
Seasonal Energy Efficiency Ratio (SEER)	A measurement of the efficiency of a central air conditioner over an entire season. In technical terms, SEER is a measure of equipment the total cooling of a central air conditioner or heat pump (in Btu) during the normal cooling season as compared to the total electric energy input (in watt-hours) consumed during the same period.
Seasonal Peak kW	See Summer/Winter Seasonal Peak kW, and Summer/Winter On-Peak Peak kW.
Sector	A system for grouping customers with similar characteristics. For the purpose of this manual, the sectors are Commercial and Industrial (C&I), Small Business, Residential, and Low Income.
Spillover Rate	The percentage of savings attributable to the program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of (a) participants in the program who install additional energy efficient measures outside of the program as a result of hearing about the program and (b) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program.

TERM	DESCRIPTION
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.