Massachusetts
Technical Reference Manual

for Estimating Savings from Energy Efficiency Measures

2013-2015 Program Years – Plan Version

October 2012

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Introduction

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

Within this TRM, efficiency measures are organized by the sector for which the measure is eligible and by the primary energy source associated with the measure. The two sectors are Residential and Commercial & Industrial ("C&I").[1] The primary energy sources addressed in this TRM are electricity and natural gas.

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

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

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

[1] In this document, the Residential and Low Income programs are represented in a single "Residential" sector due to the degree of overlap in savings assumptions for similar measures in the standard income programs.

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The TRM in the Context of Energy Efficiency Programs

Overview

Due to the ramp-up of energy efficiency spending and savings goals in Massachusetts it is necessary for the acceleration of collaborative efforts focused on:

- Improving processes,
- Reexamining the presentation of planning efforts and reporting results,
- Developing energy efficiency analysis tools,
- Improving source and process documentation, and
- Conducting broader and deeper research initiatives.

In addition, due to the number of initiatives underway, it is important to understand the connections between these efforts. Specifically, how does the effort to create and maintain the TRM influence other efforts, and conversely, how is the TRM impacted by other efforts?

The purpose of this section is to show how the TRM fits into the process of administering energy efficiency programs in Massachusetts. This section explains how the TRM is connected to the following:

- Planning,
- Annual reporting,
- Updates to PA tracking systems,
- Evolution of program and measure cost effectiveness analysis tools,
- Evaluation, Measurement and Verification ("EM&V"),
- Planning and Reporting Information System ("PARIS"), and
- Quality control.

Planning

The PAs are submitting this version of the TRM (the 2013 TRM) to the Department of Public Utilities ("DPU") along with their three year plans for 2013-2015. This version of the 2013 TRM is called the 2013-2015 Program Year – Plan Version TRM.

While PAs use many of the same assumptions and algorithms for planning and reporting purposes, the TRM – Plan Version is not meant to document the detailed development of the PAs' planning assumptions. The TRM – Plan Version provides regulators and stakeholders with a preview of the assumptions and algorithms that the PAs will use for reporting purposes.

Annual Reporting

Each Massachusetts PA submits an Annual Report to the DPU which summarizes the results of its energy efficiency program activities. The first Annual Reports that were filed with a TRM were the 2010 Annual Reports, submitted to the DPU in the summer of 2011. The version of the TRM that was filed at that time

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was called the Program Year 2010 – Report Version TRM. The PAs will file a version of the TRM called Program Year 2013 – Report Version TRM at the same time they file the 2013 Annual Reports.

Updates to Program Administrator Tracking Systems

Each Massachusetts PA maintains its own tracking system that contains the energy efficiency data that the PA uses to meet reporting requirements set forth by the DPU. The current design of the PAs' tracking systems influences the types of assumptions and algorithms that appear in this TRM. The current algorithms leverage inputs that the PAs collect.

To the extent that assumptions and algorithms documented in the 2013-2015 TRM – Plan Version were not in use by PAs in 2012[2], PAs are committed to implementing as many of the common assumptions and algorithms contained in the TRM as are feasible in their tracking systems, or by some other means, by January 2013. If PAs cannot implement changes in time for 2013, PAs are committed to implementing these changes as soon as it is feasible. The January 2013 deadline enables the PAs to use the assumptions and algorithms documented in the 2013 TRM when calculating the savings for the 2013 Annual Reports.

Evolution of Program and Measure Cost Effectiveness Analysis Tools

The program and measure cost effectiveness analysis tools are Microsoft® Excel® workbooks used by PAs to ensure that the measures and programs that they implement meet the cost effectiveness requirements defined by the DPU in its order Investigation by the Department of Public Utilities on its own Motion into Updating its Energy Efficiency Guidelines Consistent with An Act Relative to Green Communities, D.P.U. 08-50-A (March 16, 2009).[3] The PAs also use the output from the cost effectiveness analysis tools to develop the input (data, tables, and graphs) for their Energy Efficiency Plans and Annual Reports. The PAs envision aligning the measure names and the categorization of measures in the TRM with the measure names and categorization of measures in the cost effectiveness analysis tools either directly, or through the use of a translation tool.

As stated previously, if the assumptions and algorithms documented in the 2013 TRM are not in use by PAs, the PAs are committed to implementing as many updates as are feasible in their tracking systems, or by some other means, by January 2013. Another means of implementing these updates is by updating the cost effectiveness analysis tool workbooks. For example, some PA tracking systems only calculate gross savings. In this case, any changes to assumptions or calculations that impact net savings need to be made to the cost effectiveness analysis tool workbooks, where the net savings calculations occur.

[2] In some cases, one or more PAs discovered that updates to assumptions and algorithms could not be implemented in this timeframe, or all agreed that differences are justified. In the event that an assumption or algorithm could not be implemented in this timeframe, the TRM includes a description of the alternate assumption or algorithm that the PA used to calculate savings, along with the appropriate source documentation.

[3] Please see section III. Criteria for Establishing Program Cost-Effectiveness starting on Page 6 for details.

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Evaluation, Measurement and Verification

EM&V ensures that "the programs are evaluated, measured, and verified in a way that provides confidence to the public at large that the savings are real and in a way that enables the PAs to report those savings to the Department of Public Utilities with full confidence".[4]

The 2013 Program Year – Report Version TRM will be submitted with the 2013 Annual Reports to communicate any updates to assumptions and algorithms due to key learning from EM&V results produced since the 2013-2015 Energy Efficiency Plans and Plan Version TRM were filed.

A secondary goal of creating a TRM is to identify areas where savings calculations can be improved. The TRM will inform future EM&V planning as a means to make these improvements.

Planning and Reporting Information System

PARIS is a statewide database maintained by the Department of Energy Resources ("DOER") that emulates the PAs' cost effectiveness analysis tools. PAs submit excerpts of the cost effectiveness analysis tool workbooks to DOER which DOER inputs into the PARIS database. 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 DPU and the electric PAs. Beginning with the 2010 plans, PARIS holds data from gas PAs as well. As of 2011, PARIS will hold updates made to the PA tracking systems and cost effectiveness analysis tools to align with the assumptions and algorithms shown in the 2013-2015 Plan Version TRM. PAs will submit excerpts of cost effectiveness analysis tool workbooks to DOER. DOER will input these excerpts into the PARIS database.

Quality Control

A secondary function of PARIS is to assist PAs with quality control - to ensure the calculations embodied in the cost effectiveness analysis tool workbooks are accurate. PARIS contains tools and queries which PAs use to ensure that the calculations of net savings are consistent and correct. PAs also conduct their own internal quality control on data.

Regulators and stakeholders can use the TRM to confirm that savings inputs and calculations are reasonable and reliable. However, the TRM cannot be used by regulators and stakeholders to replicate the PAs reported savings. The TRM does not provide regulators and stakeholders with data inputs at a level that is detailed enough to enable replication of the savings reported by PAs. These calculations occur within tracking systems, within separate Excel workbooks, and within cost effectiveness analysis tools. However, in the event that regulators and stakeholders request that PAs provide tracking system details, the reproduction of reported data will be possible using the TRM.

[4] Form the 2010-2012 Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan, October 29, 2009, found at: http://www.ma-eeac.org/docs/DPU-filing/ElectricPlanFinalOct09.pdf. Please see page 275.

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TRM Update Process

Overview

This section describes the process for updating the TRM. The update process is synchronized with the filing of program plans and Annual Reports by the PAs with the DPU.

Updates to the TRM can include:

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

Each TRM is associated with a specific program year, which corresponds to the calendar year. This results in two main versions of the TRM for each program year:

- the "Plan Version" is filed with the PA program plans prior to the program year, and
- the "Report Version" includes updates to the "Plan Version" document as needed and is filed with the PA Annual Reports, with the final savings algorithms and factors used to report actual savings.

The TRM for each program year is updated over time as needed to both plan for future program savings and to report actual savings.

Key Stakeholders and Responsibilities

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

Stakeholder	Responsibilities
TRM Coordinating Committee	▪ Administrative coordination of TRM activities, including: ▪ Assure collaboration and consensus by the PAs regarding TRM updates ▪ Assure updates are compiled from the PAs and incorporated into the TRM ▪ Coordinate with related program activities (e.g., evaluation and program reporting processes)
Program Administrators	▪ Provide one or two representatives each to the TRM Coordinating Committee, either by direct representation or through a proxy (e.g., GasNetworks). Both the planning and evaluation functions should be represented on the Committee. ▪ Identify needed updates to the TRM ▪ Coordinate with other PAs on all TRM updates ▪ File TRM updates with the DPU

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

TRM Update Cycle

The timeline below shows the main milestones of the TRM update cycle over a period of two years. The milestones for the program year ("PY") 2013-2015 TRM Plan and Report versions are described below the timeline.

OCTOBER 2012: The 2013-2015 PY – Plan Version TRM is filed with the PAs' program plans.

The 2013-2015 Program Year – Plan Version TRM is filed with the DPU jointly with the PAs' energy efficiency program plans. With regard to the program plans, the TRM is considered a "planning document" in that it provides the documentation for how the PAs *plan* to count savings for that program year. The TRM is not intended to fully document how the PAs develop their plan estimates for savings.

OCTOBER 2012 - JUNE 2014: The 2013 Program Year TRM will be updated as needed based on evaluation studies and any other updates that will affect reported savings for PY 2013.

After the 2013-2015 Program Year – Plan Version TRM has been filed, there may be updates to the TRM to reflect how savings are actually calculated for PY 2013. The most common updates to the TRM will result from new evaluation studies. Results of evaluation studies will be integrated into the working version of the TRM as the studies are completed. Other updates may include the results of working group discussions to achieve greater consistency among PA assumptions.

JANUARY 2013: PAs begin to track savings based on the 2013-2015 TRM

Beginning in January 2013, the PAs will track savings for PY 2013-2015 based on the 2013-2015 Program Year – Plan Version TRM.

JULY 2014: The 2013 Program Year – Report Version TRM will be filed with the PY 2013 Annual Reports

The 2013 Program Year – Report Version TRM, including any updates relative to the Program Plan version, will be filed with the PAs' Annual 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

AUGUST 2013 - OCTOBER 2013: If a 2014 MTM is to be filed the PAs prepare the 2014 Program Year – Plan Version TRM for filing with their 2014 MTM

The 2014 Program Year – Plan Version TRM will be based on previous program year versions of the TRM, updated as appropriate for the 2013 program year in preparation for filing with the 2014 MTM. Updates may include results of new evaluations or working group discussions and the addition or removal of energy efficiency measures.

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Measure Characterization Structure

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

Source citations: The source of each assumption or default parameter value should be properly referenced in a footnote. New source citations should be added to Appendix D: Table of Referenced Documents, which serves as a cross-reference to digital versions of the referenced documents.

Measure Name

A single device or behavior may be analyzed as a range of measures depending on a variety of factors which largely translate to where it is and who is using it. Such factors include hours of use, location, and baseline (equipment replaced or behavior modified). For example, the same screw-in compact fluorescent lamp will produce different savings if installed in an emergency room waiting area than if installed in a bedside lamp.

Version Date and Revision History

This section will include information regarding the history of the measure entry including when the data for that measure is effective, and the last date that the measure is offered.

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

This section will include a plain text description of the efficient and baseline technology and the benefit(s) of its installation, as well as subfields of supporting information including:

Description: <Description of the energy efficiency measure>
Primary Energy Impact: <Electric or Natural Gas>
Secondary Energy Impact: <e.g., Natural Gas, Propane, Oil, Electric, None>
Non-Energy Impact: <e.g., Water Resource, O&M, Non-Resource, None>
Sector: <Residential, Low Income or Commercial and Industrial>
Market: <Lost Opportunity, Retrofit and/or Products and Services>
End-Use: <Per PARIS database definition – see list below>
Program: <Per PA definition>

The PARIS database includes the following possible End-Uses:

Lighting	Compressed Air	Demand Response
HVAC	Behavior	Photovoltaic Panels
Motors /Drives	Insulation	Process
Refrigeration	Combined Heat and Power	
Hot Water	Solar Hot Water	

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Notes

This is an optional section for additional notes regarding anticipated changes going forward. For example, this section would not if there were upcoming statewide evaluations affecting the measure, or any plans for development of statewide tool for calculating measure savings.

Algorithms for Calculating Primary Energy Impacts

This section will describe the method for calculating the primary energy savings in appropriate units, i.e., kWh for electric energy savings or MMBtu for natural gas energy savings. The savings algorithm will be provided in a form similar to the following:

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

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

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

Below the savings algorithms, a table contains the definitions (and, in some cases, default values) of each input in the equation(s). The inputs for a particular measure may vary and will be reflected as such in this table (see example below).

ΔkWh	=	gross annual kWh savings from the measure
ΔkW	=	gross connected kW savings from the measure
Hours	=	average hours of use per year
$Watts_{BASE}$	=	baseline connected kW
$Watts_{EE}$	=	energy efficient connected kW

Baseline Efficiency

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

High Efficiency

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

Hours

This section will note operating hours for equipment that is either on or off, or equivalent full load hours for technologies that operate at partial loads, or reduced hours for controls. Reference tables will be used as needed to avoid repetitive entries.

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Measure Life

Measure Life includes equipment life and the effects of measure persistence. Equipment life is the number of years that a measure is installed and will operate until failure. Measure persistence takes into account business turnover, early retirement of installed equipment, and other reasons measures might be removed or discontinued.

Secondary Energy Impacts

This section described any secondary energy impacts associated with the energy efficiency measure, including all assumptions and the method of calculation.

Non-Energy Impacts

This section describes any non-energy impacts associated with the energy efficiency measure, including all assumptions and the method of calculation.

Impact Factors for Calculating Adjusted Gross Savings

The section includes a table of impact factor values for adjusting gross savings. Impact factors for calculating net savings (free ridership, spillover and/or net-to-gross ratio) are in Appendix B: Net to Gross Impact Factors. Further descriptions of the impacts factors and the sources on which they are based are described below the table.

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}

Abbreviated program names may be used in the above table. The mapping of full program names to abbreviated names is given below.

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	Full Program Name	Abbreviation
Residential-Electric	Residential New Construction & Major Renovation	RNC
	Residential Cooling & Heating Equipment	RHVAC
	Multi-Family Retrofit	MF Retrofit
	MassSAVE	MassSAVE
	Behavior/Feedback Program	Behavior/Feedback
	ENERGY STAR Lighting	ES Lighting
	ENERGY STAR Appliances	ES Appliances
Low Income-Electric	Low-Income Residential New Construction	LI RNC
	Low-Income 1-4 Family Retrofit	LI Retrofit 1-4
	Low-Income Multifamily Retrofit	LI MF Retrofit
C&I – Electric	C&I New Construction and Major Renovation	NC
	C&I Large Retrofit	Large Retrofit
	C&I Small Retrofit	Small Retrofit
Residential – Gas	Residential New Construction & Major Renovation	RNC
	Residential Heating and Water Savings	Residential Heating and Water Savings
	MassSAVE	MassSAVE
	Multifamily Retrofit	MF Retrofit
	Behavior/Feedback Program	Behavior/Feedback
Low Income – Gas	Low-Income Single Family Retrofit	Low-Income Single Family Retrofit
C&I - Gas	C&I New Construction & Major Renovation	C&I NC
	C&I Retrofit	C&I Retrofit
	C&I Direct Install	C&I Direct Install

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Impact Factors for Calculating Adjusted Gross and Net Savings

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

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

Types of Impact Factors

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

Impact factors used to adjust gross savings:

- In-Service Rate ("ISR")
- 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

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impact evaluation to the estimated measure savings derived from the savings algorithms. The realization rate does not include the effects of any other impact factors. Depending on the impact evaluation study, there may be separate realization rates for energy (kWh), peak demand (kW), or fossil fuel energy (MMBtu).

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

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

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

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

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

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

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

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

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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

$$adj_gross_MMBtu = gross_MMBtu \times RR_E \times SPF \times ISR$$
$$net_MMbtu = adj_gross_MMBtu \times NTG$$

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)

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$adj_gross_kW_{WP}$	=	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 for electric energy (kWh)
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

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Residential Electric Efficiency Measures

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Behavior – Basic Educational Measures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of basic educational measures during an audit to help customers become more aware of energy efficiency.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Behavior
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \max(\Delta kW_{SP}, \Delta kW_{WP})$$

Where:
Unit = Completed audit
ΔkWh = Average annual kWh savings per unit: 25 kWh[5]
ΔkW = Max kW Reduction: 0.005 kW[6]

Cape Light Compact savings:
Unit = Completed audit TLC kit includes 2 faucet aerators, LED night light, drip gauge, hot water thermometer and 12 wall plate stoppers.
ΔkWh = Average annual kWh savings per unit: 126 kWh[7]
ΔkW = Max kW Reduction: 0.027 kW[8]

Baseline Efficiency

The baseline efficiency case assumes no measures installed.

[5] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[6] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[7] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts use sum of measures offered in kit from table 42.
[8] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators

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High Efficiency

The high efficiency case includes basic educational measures such as LED nightlights, refrigerator thermostats, hot water thermostats, refrigerator coil brush, wall plate stoppers, and low flow showerheads and aerators for CLC.

Hours

Not applicable.

Measure Life

The measure life is 5 years.[9]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Baseload	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[10]

[9] Massachusetts Common Assumption.
[10] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Behavior – Energy Use Reports

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: The Behavior/Feedback programs send energy use reports to participating electric customers in order to change customers' energy-use behavior.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Products and Services
End Use: Behavior
Program: Behavior/Feedback Program

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = (kWh_{BASE})(\%SAVE)$$
$$\Delta kW = \max(\Delta kW_{SP}, \Delta kW_{WP})$$

Where:
Unit = One participant household.
kWh_{BASE} = Baseline consumption of kWh. See Table 1
%SAVE = Energy savings percent per program participant. See Table 1[11]
ΔkW = See Table 1[12]

Table 1: Savings Factors for OPOWER Electric

			2013			2014			2015		
PA	**Measure Name**	**kWh BASE**	**% Save**	**ΔkWh**	**ΔkW**	**% Save**	**ΔkWh**	**ΔkW**	**% Save**	**ΔkWh**	**ΔkW**
National Grid	Group 2009	11,233	2.25%	253.25	0.0532	2.26%	254.09	0.053	2.25%	253.25	0.053
National Grid	Group 2010	12,370	1.83%	226.43	0.0476	1.84%	227.19	0.048	1.83%	226.44	0.048
National Grid	Group 2010 Added	15,232	1.88%	65.98	0.0139	1.81%	276.06	0.058	1.81%	275.16	0.058
National Grid	Group 2011	9,638	2.14%	205.98	0.0433	2.16%	208.43	0.044	2.16%	207.73	0.044

[11] Opinion Dynamics Corporation and Navigant Consulting (2011). Massachusetts Cross-Cutting Behavioral Program Evaluation. Updated with vendor projections for kwh_{base} and %SAVE for 2013-2015.
[12] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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National Grid	Group 2011 Added	6,121	2.38%	33.64	0.0071	2.38%	145.77	0.031	2.37%	145.26	0.031
National Grid,	Group 2012	6,126	2.07%	126.92	0.0267	2.46%	150.70	0.032	2.46%	150.80	0.032
National Grid,	Group 2012 Dual	6,239	2.05%	127.97	0.0269	2.43%	151.75	0.032	2.43%	151.85	0.032
National Grid	Group 2013	8,036	0.94%	84.04	0.0176	1.68%	153.33	0.032	2.07%	176.71	0.037
National Grid	Group 2014	7,093	n/a	n/a	n/a	1.01%	71.57	0.015	1.85%	131.00	0.028
National Grid	Group 2015	7,093	n/a	n/a	n/a	n/a	n/a	n/a	1.01%	71.57	0.015
NSTAR	Group 2012a	13,027	1.94%	253.16	0.0577	2.21%	287.36	0.0656	2.28%	297.04	0.0678
NSTAR	Group 2012b	11,388	1.80%	205.00	0.0468	2.20%	250.29	0.0571	2.24%	254.85	0.0581
NSTAR	Group 2013	8,423	1.13%	95.14	0.0194	1.85%	161.29	0.0350	2.09%	182.01	0.0395
NSTAR	Group 2014	n/a	n/a	n/a	n/a	1.01%	88.34	0.0201	1.76%	153.62	0.0350

Baseline Efficiency

The baseline efficiency case is a customer who does not receive OPOWER reports.

High Efficiency

The high efficiency case is a customer who receives an OPOWER report.

Hours

Not applicable.

Measure Life

The measure life is 1 year.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

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Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
OPOWER Group	Behavior/Feedback	National Grid, NSTAR	1.00	1.00	1.00	1.00	1.00	0.73	1.00

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

Savings Persistence Factor
Savings persistence is 100% since the measure life for each participant is 1 year.

Realization Rates
Realization rates are 100% because deemed savings are based on assumptions from year-to-date vendor findings, which are then verified by impact analysis.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[13]

[13] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Lighting – CFL Bulbs

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Compact fluorescent lamps offer comparable luminosity to incandescent lamps at significantly less wattage and significantly longer lamp lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity
End Use: Lighting
Program: ENERGY STAR Lighting, Residential New Construction & Major Renovation, Home Energy Services, Low-Income Residential New Construction, Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (NSTAR, WMECO)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Rebated CFL Bulb
ΔkWh = Average annual kWh reduction. See Table 2.[14]
ΔkW = Average kW reduction. See Table 2. [15,16]

[14] Energy savings are calculated from kW savings and hours of use.
[15] NMR Group (2012). *Baseline Sensitivity Analysis Spreadsheet, Three-Year Planning Version.* Prepared for the Massachusetts PAs.
[16] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT; Page 56.

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Table 2: Savings for Residential CFL Bulbs

Measure	Program	PA	2013 ΔkW	2014 ΔkW	2015 ΔkW	Hours	2013 ΔkWh	2014 ΔkWh	2015 ΔkWh
Screw-in Bulbs	ES Lighting, RNC, LI RNC	All	0.048	0.043	0.042	1,022	48.7	44.3	43.0
Screw-in Bulbs (Hard to Reach)	ES Lighting	All	0.048	0.043	0.042	1,022	48.7	44.3	43.0
Screw-in Bulbs (School Fundraiser)	ES Lighting	All	0.048	0.043	0.042	1,022	48.7	44.3	43.0
Screw-in Bulbs (Specialty Bulbs)	ES Lighting	All	0.048	0.043	0.042	1,022	48.7	44.3	43.0
Screw-in Bulbs (EISA Exempt Baseline)	ES Lighting	All	0.046	0.046	0.046	1,022	47.0	47.0	47.0
Screw-in Bulbs	HES	All	0.011[17]	0.009	0.008	n/a	35.0[18]	31.0	26.0
Screw-in Bulbs (piggyback)	HES	All	0.011[19]	0.009	0.008	n/a	35.0	31.0	26.0
CFL Bulb	LI 1-4 Retrofit	All	0.012[20]	0.011	0.009	n/a	41.0[21]	36.0	30.0
CFL Bulb	LI MF Retrofit	NSTAR, WMECO	0.012[22]	0.011	0.009	n/a	41.0	36.0	30.0

Baseline Efficiency

The baseline efficiency case is an incandescent bulb.

High Efficiency

The high efficiency case is an ENERGY STAR® rated CFL spiral bulb.

Hours

Average annual operating hours for bulbs are 1,022 hours/year (2.8 hours/day[23] * 365 days/year).

[17] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[18] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[19] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[20] Ibid.
[21] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[22] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[23] Nexus Market Research and RLW Analytics (2008). *Residential Lighting Measure Life Study*. Prepared for New England Residential Lighting Program Sponsors.

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Measure Life

The measure life for bulbs with an EISA exempt baseline is 8 years.[24] The adjusted measure life is 6 years for screw-in bulbs in 2013, 2014 and 2015.[25]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Screw-in Bulbs	ES Lighting	All	0.95	1.00	1.00	1.00	1.00	0.11	0.22
Screw-in Bulbs (Hard to Reach)	ES Lighting	All	1.00	1.00	1.00	1.00	1.00	0.11	0.22
Screw-in Bulbs (School Fundraiser)	ES Lighting	All	0.50	1.00	1.00	1.00	1.00	0.11	0.22
Screw-in Bulbs (Specialty Bulbs)	ES Lighting	All	0.95	1.00	1.00	1.00	1.00	0.11	0.22
Screw-in Bulbs (EISA Exempt Baseline)	ES Lighting	All	0.95	1.00	1.00	1.00	1.00	0.11	0.22
Screw-in Bulbs	RNC, LI RNC	All	0.99	1.00	1.00	1.00	1.00	0.11	0.22
Screw-in Bulbs	HES	All	1.00	1.00	1.00	1.00	1.00	0.17	1.00
Screw-in Bulbs (piggyback)	HES	All	1.00	1.00	1.00	1.00	1.00	0.17	1.00
CFL Bulb	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.17	1. 00
CFL Bulb	LI MF Retrofit	NSTAR, WMECO	1.00	1.00	1.00	1.00	1.00	0.17	1.00

In-Service Rate

- ES Lighting, LI 1-4 Retrofit, LI MF Retrofit: PAs assume a 100% installation rate for direct install programs.
- RNC, LI RNC: 2006 ENERGY STAR® Homes New Homebuyer Survey Report[26]
- HES: Impact evaluation of the HES program[27]

Savings Persistence Factor

All PAs use 100% savings persistence factors.

Realization Rates

[24] The calculated measure life for screw-in bulbs is 8, based on a component life of 8,000 and hours of use of 1,022.
[25] MA PAs (2012). 2013-15 MA Lighting Worksheet
[26] Nexus Market Research & Dorothy Conant (2006). *Massachusetts ENERGY STAR® Homes: 2005 Baseline Study: Part II: Homeowner Survey Analysis Incorporating Inspection Data Final Report.* Prepared for the Massachusetts Joint Management Committee.
[27] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

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Realization rates are 100% since savings estimates are based on evaluation results.

Coincidence Factors

- ES Lighting, RNC, LI RNC: Coincidence factors are based on the 2009 Lighting Markdown Study.[28]
- HES, LI MF Retrofit, LI 1-4 Retrofit: Coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[29]

[28] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT.
[29] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Lighting – Indoor Fixtures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of ENERGY STAR® compact fluorescent (CFL) indoor fixtures. Compact fluorescent fixtures offer comparable luminosity to incandescent fixtures at significantly less wattage and significantly longer lifetimes. Hardwired fluorescent fixtures offer comparable luminosity to incandescent fixtures at significantly lower wattage and offer significantly longer lifespan.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity, Retrofit
End Use: Lighting
Program: Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (NSTAR, WMECO), ENERGY STAR Lighting, Residential New Construction & Major Renovation, Low-Income Residential New Construction

Algorithms for Calculating Primary Energy Impact

For Low-Income 1-4 Family Retrofit and Low-Income Multifamily Retrofit (NSTAR, WMECO) unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Installation of CFL fixture
ΔkWh = Average annual kWh reduction: 140 kWh[30]
ΔkW = Max kW reduction: 0.027[31]

For ENERGY STAR Lighting, Residential New Construction & Major Renovation, Low-Income Residential New Construction unit savings are based on the following algorithms which use averaged inputs.

ΔkWh = Average # of bulbs per fixture x Average annual kWh savings x EISA factor
$$\Delta kW = \Delta kW$$

[30] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts
[31] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Where:

Average Number of Bulbs[32]	Average ΔkWh[33]	2013 EISA Factor[34]	2014 EISA Factor	2015 EISA Factor
2.6	44	0.95	0.86	0.84

Table 3: Savings for Residential Indoor Fixtures

Measure	Program	PA	2013 ΔkW	2014 ΔkW	2015 ΔkW	2013 ΔkWh	2014 ΔkWh	2015 ΔkWh
Indoor Fixture	ES Lighting	All	0.106	0.097	0.094	109	99	96
Indoor Fixture	RNC, LI RNC	All	0.106	0.097	0.094	109	99	96

Baseline Efficiency

The baseline efficiency case is an incandescent, screw-based fixture with an incandescent lamp.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified compact fluorescent light fixture wired for exclusive use with pin-based CFLs.

Hours

The average annual operating hours are 912.5 hours/year (2.5 hours/day[35] * 365 days/year) for ES Lighting, RNC and LI RNC.

Measure Life

The adjusted measure life is 11 years in 2013 and 12 years in 2014 and 2015 for indoor fixtures.[36]

Secondary Energy Impact

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[32] Energy Market Innovations Inc. (2007). *Puget Sound Area Residential Compact Fluorescent Lighting Market Saturation Study.* Prepared for Puget Sound Energy, Seattle City Light, Snohomish County PUD.
[33] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs.* Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Table 1-8.
[34] NMR Group (2012). *Baseline Sensitivity Analysis Spreadsheet, Three-Year Planning Version.* Prepared for the Massachusetts PAs.
[35] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs.* Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Page 104.
[36] MA PAs (2012). 2013-15 MA Lighting Worksheet

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Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Indoor Fixture	ES Lighting	All	0.95	1.00	1.00	1.00	1.00	0.11	0.22
Indoor Fixture	RNC, LI RNC	All	0.96	1.00	1.00	1.00	1.00	0.11	0.22
CFL Fixture	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.17	1.00
CFL Fixture	LI MF Retrofit	NSTAR, WMECO	1.00	1.00	1.00	1.00	1.00	0.17	1.00

In-Service Rates

- ES Lighting: 2004 Impact Evaluation of MA, RI, VT Residential Lighting Program[37]
- RNC, LI RNC: 2006 ENERGY STAR® Homes New Homebuyer Survey Report[38]
- LI 1-4 Retrofit, LI MF Retrofit: PAs assume 100% in-service rates.

Savings Persistence Factor

All PAs use 100% savings persistence factors.

Realization Rates

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

Coincidence Factors

Summer and winter coincidence factors for CFL Fixtures in LI 1-4 Retrofit and LI MF Retrofit are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[39] Coincidence factors for indoor fixtures are based on the 2009 Lighting Markdown Study.[40]

[37] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Page 11.
[38] Nexus Market Research & Dorothy Conant (2006). *Massachusetts ENERGY STAR® Homes: 2005 Baseline Study: Part II: Homeowner Survey Analysis Incorporating Inspection Data Final Repor*t. Prepared for the Massachusetts Joint Management Committee; Table 8.1
[39] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators..
[40] Nexus Market Research and RLW Analytics (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT.

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Lighting – Outdoor Fixtures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of hardwired ENERGY STAR® fluorescent outdoor fixtures with pin-based bulbs. Savings for this measure are attributable to high efficiency outdoor lighting fixtures and are treated similarly to indoor fixtures.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity, Retrofit
End Use: Lighting
Program: ENERGY STAR Lighting

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms which use averaged inputs:

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

Where:

Unit	=	Rebated outdoor fixture
ΔkWh	=	Average annual kWh reduction: 156 kWh (calculated)
ΔkW	=	Average connected kW reduction: 0.095 kW[41]
Hours	=	Average annual operating hours

Baseline Efficiency

The baseline efficiency case is an incandescent, screw-based fixture with an incandescent bulb.

High Efficiency

The high efficiency case is an ENERGY STAR® fixture wired for exclusive use with a pin based CFL.

Hours

The average annual operating hours are 1,642.5 hours/year (4.5 hours per day[42] * 365 days per year).

[41] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Table 1-8.

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Measure Life

The measure life is 6 years.[43]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Outdoor Fixture	ES Lighting	All	0.87	1.00	1.00	1.00	1.00	0.11	0.22

In-Service Rates
2004 Impact Evaluation of MA, RI, VT Residential Lighting Program[44]

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on the 2009 Lighting Markdown Study.[45]

[42] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Page 104
[43] Nexus Market Research and RLW Analytics (2008). *Residential Lighting Measure Life Study*. Prepared for New England Residential Lighting Program Sponsors; Page 1.
[44] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Page 11.
[45] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT.

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Lighting – Torchieres

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of high-efficiency ENERGY STAR® torchieres. High efficiency torchieres use fluorescent in place of halogen or incandescent bulbs to provide comparable luminosity at significantly reduced wattage.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity, Retrofit
End Use: Lighting
Program: ENERGY STAR Lighting, Home Energy Services, Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (CLC, NSTAR, WMECO)

Algorithms for Calculating Primary Energy Impact

For Low-Income 1-4 Family Retrofit and Low-Income Multifamily Retrofit

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

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

Where:
Unit = Rebated ENERGY STAR® Torchiere
ΔkWh = Average annual kWh reduction: 211 kWh[46]
ΔkW = Average connected kW reduction: 0.064 kW[47]

For ENERGY STAR Lighting and HES

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

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

[46] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[47] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Where:
Unit = Rebated ENERGY STAR® Torchiere
ΔkWh = Average annual kWh reduction: 106 kWh (calculated)
ΔkW = Average connected kW reduction: 0.088 kW[48]
Hours = Average annual operating hours

Baseline Efficiency

The baseline efficiency case is a halogen or incandescent torchiere fixture.

High Efficiency

The high efficiency case is a fluorescent torchiere fixture.

Hours

The average annual operating hours are 1,204.5 hours/year (3.3 hours/day[49] * 365 days/year) for ENERGY STAR Lighting.

Measure Life

The measure life is 8 years.[50]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Torchieres	ES Lighting	All	0.83	1.00	1.00	1.00	1.00	0.11	0.22
Torchieres	HES	CLC only	0.83	1.00	1.00	1.00	1.00	0.11	0.22
Torchieres	LI 1-4 Retrofit	CLC only	1.00	1.00	1.00	1.00	1.00	0.11	0.22

[48] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Table 1-8. Adjusted to account for changes to the baseline technology.
[49] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Page 104
[50] Ibid.

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Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Torchieres	LI MF Retrofit	CLC, NSTAR, WMECO	1.00	1.00	1.00	1.00	1.00	0.11	0.22

In-Service Rates
- ES Lighting, HES: 2004 Impact Evaluation of MA, RI, VT Residential Lighting Program[51]
- Low Income: Assumed to be 100% for Low-Income customers.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on the 2009 Lighting Markdown Study.[52]

[51] Nexus Market Research and RLW Analytics (2004). *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs*. Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR and Unitil Energy Systems, Inc.; Page 11.
[52] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT.

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Lighting – LED Bulbs

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of Light-Emitting Diode (LED) screw-in bulbs. LEDs offer comparable luminosity to incandescent bulbs at significantly less wattage and significantly longer lamp lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: Lighting
Program: ENERGY STAR Lighting, Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (NSTAR, WMECO), Residential New Construction & Major Renovation, Low-Income Residential New Construction

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Rebated LED bulb
ΔkWh	=	Average annual energy savings: See Table 4 [53,54]
ΔkW	=	Average connected kW reduction: See Table 4[55]

Baseline Efficiency

The baseline efficiency case is a 65-watt incandescent bulb in a screw-based socket or fluorescent under cabinet light.

High Efficiency

The high efficiency case is an 18-watt LED downlight.

[53] NMR Group (2012). *Baseline Sensitivity Analysis Spreadsheet, Three-Year Planning Version.* Prepared for the Massachusetts PAs.
[54] Homes: Energy Star. *LED Light Bulbs for Consumers. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=ILB. Accessed on 10/15/10.*
[55] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Table 4: Savings for Residential LED Bulbs and Fixtures

Measure	Program	2013 ΔkW	2014 ΔkW	2015 ΔkW	Hours	2013 ΔkWh	2014 ΔkWh	2015 ΔkWh
LED Bulb	ES Lighting, LI 1-4 Retrofit, RNC, LI RNC, LI MF (NSTAR, WMECO)	0.040	0.036	0.034	1,022	41	37	35
LED (EISA Exempt Baseline)	ES Lighting	0.047	0.047	0.047	1,022	48	48	48

Hours

The average annual operating hours are 1, 022 hours/year (2.8 hours/day[56] * 365 days/year).

Measure Life

The measure life for LED (EISA Exempt Baseline) is 20 years.[57] The adjusted measure life for LED bulbs is 12 years in 2013, and 13 years in 2014 and 2015.[58]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

No operations and maintenance cost adjustments are claimed for this measure. At this time, the incremental cost is unclear given the continual changes in LED technology. In addition, the measure life savings from not replacing incandescent bulbs are also unclear.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Bulb	ES Lighting, LI 1-4 Retrofit, RNC, LI RNC, LI MF (NSTAR, WMECO)	All	1.00	1.00	1.00	1.00	1.00	0.11	0.22
LED (EISA Exempt Baseline)	ES Lighting	All	1.00	1.00	1.00	1.00	1.00	0.11	0.22

[56] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT; Page 6.
[57] Expected lifetime from ENERGY STAR ®.
[58] MA PAs (2012). 2013-15 MA Lighting Worksheet

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are from the 2009 Lighting Markdown Study.[59]

[59] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT.

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Lighting – LED Fixtures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of Light-Emitting Diode (LED) fixtures. LEDs offer comparable luminosity to incandescent bulbs at significantly less wattage and significantly longer lamp lifetimes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: Lighting
Program: ENERGY STAR Lighting, Residential New Construction & Major Renovation, Low-Income Residential New Construction

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithms which use averaged inputs.

ΔkWh = Average annual kWh savings x EISA factor
$\Delta kW = \Delta kW$

Where:

Average ΔkWh[60]	2013 EISA Factor[61]	2014 EISA Factor	2015 EISA Factor
48	0.93	0.84	0.80

Table 5: Savings for Residential LED Fixtures

Measure	Program	2013 ΔkW	2014 ΔkW	2015 ΔkW	2013 ΔkWh	2014 ΔkWh	2015 ΔkWh
LED Fixtures	ES Lighting	0.044	0.040	0.038	44.7	40.4	38.6
LED Fixtures	RNC, LI RNC	0.044	0.040	0.038	44.7	40.4	38.6

Baseline Efficiency

The baseline efficiency case is a 65-watt incandescent bulb in a screw-based socket or fluorescent under cabinet light.

[60] Homes: Energy Star. *LED Light Bulbs for Consumers. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=ILB. Accessed on 10/15/10.*
[61] MA PAs (2012). 2013-15 MA Lighting Worksheet

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High Efficiency

The high efficiency case is an LED fixture.

Hours

The average annual operating hours are 1, 022 hours/year (2.8 hours/day[62] * 365 days/year).

Measure Life

The adjusted measure life for LED bulbs and fixtures is 12 years in 2013, and 13 years in 2014 and 2015.[63]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

No operations and maintenance cost adjustments are claimed for this measure. At this time, the incremental cost is unclear given the continual changes in LED technology. In addition, the measure life savings from not replacing incandescent bulbs are also unclear.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
LED Fixture	ES Lighting	All	1.00	1.00	1.00	1.00	1.00	0.11	0.22
LED Fixture	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	0.11	0.22

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are from the 2009 Lighting Markdown Study.[64]

[62] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT; Page 6.
[63] MA PAs (2012). 2013-15 MA Lighting Worksheet.
[64] Nexus Market Research, RLW Analytics and GDS Associates (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT.

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Hot Water – DHW Measures (Electric)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of domestic hot water (DHW) measures including low flow showerheads, faucet aerators, and tank and pipe wraps in homes with electric water heating.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Residential Water, Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Hot Water
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Household with hot water efficiency measures installed
ΔkWh	=	Average annual kWh savings per unit: 128 kWh[65]
ΔkW	=	Average annual kW reduction per unit: 0.019 kW[66]

Cape Light Compact:
Cape Light Compact only installs pipe wrap under the Domestic Hot Water Measure Category for the Low Income Program.

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Household with hot water efficiency measures installed
ΔkWh	=	Average annual kWh savings per unit: 41 kWh[67]
ΔkW	=	Average annual kW reduction per unit: 0.006 kW[68]

[65] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[66] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[67] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.

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Baseline Efficiency

The baseline efficiency case is the existing hot water equipment.

High Efficiency

The high efficiency case includes low flow showerheads and faucet aerators as well as tank and pipe wraps.

Hours

Not applicable.

Measure Life

The measure life is 7 years.[69]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings per participant[70]	4,028 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
DHW Measures (Electric)	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.94

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors

[68] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[69] Massachusetts Common Assumption.
[70] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators

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Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[71]

[71] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Hot Water – DHW Measures (Oil, Gas and Other)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of domestic hot water (DHW) measures including low flow showerheads, faucet aerators, and tank and pipe wraps in homes that have oil or gas water heaters.
Primary Energy Impact: Oil or Gas
Secondary Energy Impact: None
Non-Energy Impact: Residential Water, Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Hot Water
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

No electric savings are claimed for this measure.

Baseline Efficiency

The baseline efficiency case is the existing hot water equipment.

High Efficiency

The high efficiency case includes low flow showerheads and faucet aerators as well as tank and pipe wraps.

Hours

Not applicable.

Measure Life

The measure life is 7 years.[72]

[72] Massachusetts Common Assumption.

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Secondary Energy Impacts

Measure	PA	Energy Type	ΔMMBtu/Unit[73]
DHW Measures (Gas/Propane)	All expect CLC	NG – Residential DHW	0.5
DHW Measures (Gas/Propane)	CLC	NG – Residential DHW	0.4
DHW Measures (Oil)	All expect CLC	Oil	0.7
DHW Measures (Oil)	CLC	Oil	0.4

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Residential water savings per participant[74]	4,028 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
DHW Measures (Gas/Other)	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
DHW Measures (Oil)	LI 1-4 Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
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.

[73] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts..
[74] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators

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Hot Water – Showerheads

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: An existing showerhead with a high flow rate is replaced with a new low flow showerhead.
Primary Energy Impact: Electric
Secondary Energy Impact: Oil
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential
Market: Retrofit
End Use: Hot Water
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

For electric water heating unit savings are deemed based on study results:

Where:

Unit	=	Household with showerheads installed
ΔkWh	=	Average annual kWh savings per unit: 237 kWh[75]
ΔkW	=	Average annual kW reduction per unit: 0.035 kW[76]

Baseline Efficiency

The baseline efficiency case is the existing showerhead with a high flow.

High Efficiency

The high efficiency case is a low flow showerhead.

Hours

Not applicable.

Measure Life

The measure life is 7 years[77]

[75] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[76] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[77] Massachusetts common assumption

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Secondary Energy Impacts

For oil water heating unit savings are deemed based on study results:

Where:
Units = Number of showerheads.
ΔMMBtu = Annual MMBtu savings per unit. 1.3 MMBtu[78]

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Gallons water saved per year per unit that received DHW measures[79]	3,696 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Showerhead	HES	All	1.00	1.00	1.00	1.00	1.00	1.00	0.94

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[80]

[78] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[79] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators
[80] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Hot Water – Faucet Aerator

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: An existing faucet aerator with a high flow rate is replaced with a new low flow showerhead.
Primary Energy Impact: Electric
Secondary Energy Impact: Oil
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential
Market: Retrofit
End Use: Hot Water
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

Where:

Unit	=	Household with faucet aerator installed
ΔkWh	=	Average annual kWh savings per unit: 49 kWh[81]
ΔkW	=	Average annual kW reduction per unit: 0.007 kW[82]

Baseline Efficiency

The baseline efficiency case is the existing faucet aerator with a high flow.

High Efficiency

The high efficiency case is a low flow faucet aerator.

Hours

Not applicable.

Measure Life

The measure life is 7 years[83]

[81] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[82] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[83] Massachusetts common assumption

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Secondary Energy Impacts

For oil water heating unit savings are deemed based on study results:

Where:
Units = Number of faucet aerators.
ΔMMBtu = Annual MMBtu savings per unit. 0.3 MMBtu[84]

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Gallons water saved per year per unit that received DHW measures[85]	332 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Faucet Aerator	HES	All	1.00	1.00	1.00	1.00	1.00	1.00	0.94

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[86]

[84] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[85] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators
[86] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Hot Water – Indirect Water Heater

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of an indirect water heater.
Primary Energy Impact: None
Secondary Energy Impact: Oil
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Hot Water
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

There are no electric savings associated with this measure.

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 oil boiler.

Hours

Not applicable.

Measure Life

The measure life is 20 years. [87]

Secondary Energy Impacts

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Number of indirect water heaters installed.
ΔMMBtu = Annual savings per unit is 6.4 MMBtu[88]

[87] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.

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Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Indirect Water Heater	HES	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[88] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.

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Hot Water – Waterbed Mattress Replacement

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Replacement of waterbed mattress with a standard mattress.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Hot Water
Program: Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Mattress replacement
ΔkWh	=	Average annual energy reduction per unit: 872 kWh[89]
ΔkW	=	Average demand reduction per unit: 0.186 kW for LI 1-4 Retrofit and 0.165 for LI MF Retrofit[90]

Baseline Efficiency

The baseline efficiency case is an existing waterbed mattress.

High Efficiency

The high efficiency case is a new standard mattress.

Hours

Not applicable.

[89] The Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[90] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 10 years.[91]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Waterbed	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Waterbed	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.67	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[92]

[91] See the response to the question "How do I know when I need to buy a new mattress?" at the following link for more details: http://www.serta.com/#/best-mattress-FAQs-mattresses-Serta-Number-1-Best-Selling-Mattress.html (8/19/2010).
[92] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Hot Water – Heat Pump Water Heater (Electric)

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of a heat pump water heater (HPWH) instead of an electric resistance water heater.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity, Low-Income
End Use: Hot Water
Program: Residential Cooling & Heating Equipment, Low-Income 1-4 Family Retrofit, Low Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on preliminary study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Household with heat pump water heater installed
ΔkWh = Average annual energy savings per unit. See table below.
ΔkW = Average peak winter demand reduction per unit. See table below.

HPWH Size	ΔkW[93]	ΔkWh[94]
50 gallon	0.37	1,775
80 gallon*	0.37	2,672

*Not offered starting in 2015 due to upcoming Federal Standards

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.

[93] Steven Winter Associates, Inc (2012). *Heat Pump Water Heaters Evaluation of Field Installed Performance*. Sponsored by National Grid and NSTAR. Table 1.
[94] Ibid.

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Hours

Not applicable.

Measure Life

The measure life is 10 years.[95]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
HPWH (Electric)	HVAC	All	1.00	1.00	1.00	1.00	1.00	0.47	1.00
HPWH (Electric)	RNC	CLC	1.00	1.00	1.00	1.00	1.00	0.47	1.00
HPWH (Electric)	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.47	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

[95] Based on warranty of equipment.
[96] Steven Winter Associates, Inc (2012). *Heat Pump Water Heaters Evaluation of Field Installed Performance*. Sponsored by National Grid and NSTAR.

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Hot Water – Heat Pump Water Heater (Propane)

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of a heat pump water heater (HPWH) instead of an oil or propane water heater.
Primary Energy Impact: Propane
Secondary Energy Impact: Electric
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Hot Water
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

HPWH Size	Energy Type	ΔMMBtu/Unit[97]
50 Gallon	Propane	10.34
80 Gallon	Propane	14.68

Baseline Efficiency

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

High Efficiency

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

Hours

Not applicable.

Measure Life

The measure life is 10 years.[98]

[97] Steven Winter Associates, Inc (2012). *Heat Pump Water Heaters Evaluation of Field Installed Performance*. Sponsored by National Grid and NSTAR.
[98] Based on warranty of equipment.

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Secondary Energy Impacts

There is an electric penalty for this measure since the HPWH uses more electricity than the baseline propane water heater, see table below.

HPWH Size	kWh Penalty[99]	kW Penalty[100]
80 Gallon	-1,643	-1.18
50 Gallon	-1,579	-1.18

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
HPWH (Oil and Propane)	RHVAC	All	1.00	1.00	0.00	0.00	0.00	0.47	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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.[101]

[99] Steven Winter Associates, Inc (2012). *Heat Pump Water Heaters Evaluation of Field Installed Performance*. Sponsored by National Grid and NSTAR.
[100] Ibid.
[101] Steven Winter Associates, Inc (2012). *Heat Pump Water Heaters Evaluation of Field Installed Performance*. Sponsored by National Grid and NSTAR.

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HVAC – Central Air Conditioning

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of high efficiency Central AC systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

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

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

Where:

Unit	=	Installation of central AC system
Tons	=	Cooling capacity of AC equipment: Current default is 3 tons[102]
$SEER_{BASE}$	=	Seasonal Energy Efficiency Ratio of baseline AC equipment
$SEER_{EE}$	=	Seasonal Energy Efficiency Ratio of new efficient AC equipment. See Table 6
EER_{BASE}	=	Energy Efficiency Ratio of base AC equipment
EER_{EE}	=	Energy Efficiency Ratio of new efficient AC equipment. See Table 6
Hours	=	Equivalent full load hours

Baseline Efficiency

The baseline efficiency case is a central air-conditioning system with SEER = 13 and EER = 11.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified Central AC system. Average rated efficiency by measure is shown in the table below.

[102] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.

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Table 6: Savings for Residential Central Air Conditioners

Measure	EER_{EE}	$SEER_{EE}$	ΔkW	ΔkWh
CoolSmart AC (SEER 14.5 / EER 12.0)	12.0	14.5	0.273	103
CoolSmart AC (SEER 15.0 / EER 12.5)	12.5	15.0	0.393	133
CoolSmart AC (SEER 15.0 / EER 13.0)	13.0	15.0	0.503	133
CoolSmart AC (SEER 16.0 / EER 13.0)	13.0	16.0	0.503	187

Hours

The equivalent full load cooling hours are 360 hours per year.[103]

Measure Life

The measure life is 18 years.[104]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart AC	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results.[105]

[103] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[104] 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.
[105] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Air Source Heat Pump

Version Date and Revision History

Draft Date: 10/22/2010
Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of high efficiency Air Source Heat Pumps.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

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

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

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

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

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Where:

Unit	=	Installation of heat pump system
Tons	=	Capacity of HP equipment: Current default is 3 tons[106]
$SEER_{BASE}$	=	Seasonal efficiency of baseline HP equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient HP equipment. See Table 7
EER_{BASE}	=	Peak efficiency of base HP equipment[107]
EER_{EE}	=	Peak efficiency of new efficient HP equipment. See Table 7
$HSPF_{BASE}$	=	Heating efficiency of baseline HP equipment
$HSPF_{EE}$	=	Heating efficiency of new efficient HP equipment. See Table 7
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating

Baseline Efficiency

In 2013 and 2014, the baseline efficiency case is an air-source heat pump with SEER = 13, EER = 11and HSPF = 7. 7. In 2015, the baseline efficiency case is an air-source heat pump with SEER = 14, EER = 11.85 and HSPF = 8.2

High Efficiency

The high efficiency case is an ENERGY STAR® qualified Air Source Heat Pump.

Table 7: Savings for Residential Air-Source Heat Pumps

Year	Measure	EER_{EE}	$SEER_{EE}$	$HSPF_{EE}$	ΔkW_C	ΔkW_H	ΔkWh
2013, 2014	CoolSmart HP (SEER 14.5 / EER 12.0 / HSPF 8.2)	12.0	14.5	8.2	0.273	0.347	519
2013, 2014	CoolSmart HP (SEER 15.0 / EER 12.5 / HSPF 8.5)	12.5	15.0	8.5	0.393	0.502	735
2013, 2014	CoolSmart HP (SEER 16.0 / EER 12.5 / HSPF 8.5)	12.5	16.0	8.5	0.393	0.502	789
2013, 2014	CoolSmart HP (SEER 16.0 / EER 13 / HSPF 8.5)	13.0	16.0	8.5	0.503	0.502	789
2015	CoolSmart HP (SEER 14.5 / EER 12.0 / HSPF 8.2)	12.0	14.5	8.2	0.038	0.000	32
2015	CoolSmart HP (SEER 15.0 / EER 12.5 / HSPF 8.5)	12.5	15.0	8.5	0.158	0.155	248
2015	CoolSmart HP (SEER 16.0 / EER 12.5 / HSPF 8.5)	12.5	16.0	8.5	0.158	0.155	302
2015	CoolSmart HP (SEER 16.0 / EER 13 / HSPF 8.5)	13.0	16.0	8.5	0.269	0.155	302

Hours

Equivalent full load hours are 1200 hours/year for heating[108] and 360 hours/year for cooling.[109]

[106] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.
[107] AHRI (Air Conditioning, Heating, and Refrigeration Institute) (2012). Average EER of current in-market equipment with from website at http://www.ahridirectory.org/ahridirectory/pages/home.aspx. Under Directory of Certified Product Performance>Residential>Heat Pumps and Heat Pump Coils. Specified Model Status = Active, SEER Min and Max of 13, HSPF Min and Max of 7.7. SEER Min and Max of 14 and HSPF Min and Max of 8.2 used for 2015.
[108] Massachusetts Common Assumption.

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Measure Life

The measure life is 18 years.[110]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart HP	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.50

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results and Massachusetts Common Assumptions.[111]

[109] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[110] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures.* Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[111] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

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HVAC – Ductless MiniSplit Heat Pump

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of a more efficient ENERGY STAR® rated Ductless Mini Split HP system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

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

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

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

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Where:

Unit	=	Installation of high efficiency ductless Mini Split System
ΔkWh_{HP}	=	Reduction in annual kWh consumption of HP equipment
ΔkW_{HP}	=	Reduction in electric demand of HP equipment
Tons	=	Capacity of HP equipment: Current default is 1.25 tons [112]
$SEER_{BASE}$	=	Seasonal efficiency of baseline HP equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient HP equipment, see Table 8
EER_{BASE}	=	Peak efficiency of base HP equipment[113]
EER_{EE}	=	Peak efficiency of new efficient HP equipment, see Table 8
$HSPF_{BASE}$	=	Heating efficiency of baseline HP equipment
$HSPF_{EE}$	=	Heating efficiency of new efficient HP equipment, see Table 8
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating

Baseline Efficiency

In 2013 and 2014, the baseline efficiency case is a non- ENERGY STAR® rated ductless mini split heat pump with SEER 13, EER 10 and HSPF 7.7[114]. In 2015, the baseline efficiency case is a non- ENERGY STAR® rated ductless mini split heat pump with SEER 14, EER 8.5 and HSPF 8.2[115].

High Efficiency

The high efficiency case is an ENERGY STAR® qualified Ductless Mini Split System.

Table 8: Savings for Residential Ductless MiniSplit Heat Pumps

Year	Measure	$SEER_{EE}$	EER_{EE}	$HSPF_{EE}$	ΔkW_C	ΔkW_H	ΔkWh
2013, 2014	Ductless MS HP (SEER 14.5 / EER 12.0 / HSPF 8.2)	14.5	12.0	8.2	0.250	0.119	186
2013, 2014	Ductless MS HP (SEER 19, EER 12.8, HSPF 10.0)	19	12.83	10.0	0.331	0.448	669
2013, 2014	Ductless MS HP (SEER 23, EER 13, HSPF 10.6)	23	13	10.6	0.346	0.533	820
2015	Ductless MS HP (SEER 14.5 / EER 12.0 / HSPF 8.2)	14.5	12.0	8.2	0.515	0.000	13
2015	Ductless MS HP (SEER 19, EER 12.8, HSPF 10.0)	19	12.83	10.0	0.596	0.329	497
2015	Ductless MS HP (SEER 23, EER 13, HSPF 10.6)	23	13	10.6	0.611	0.414	648

Hours

The equivalent full load hours are 1200 hours/year for heating[116] and 360 hours/year for cooling.[117]

[112] Average size of mini-splits installed in 2011, per CSG.
[113] AHRI (Air Conditioning, Heating, and Refrigeration Institute) (2011). Average EER of current in-market equipment with from website at http://www.ahridirectory.org/ahridirectory/pages/home.aspx. Under Directory of Certified Product Performance>Residential>Variable Speed Mini-Split and Multi-Split Heat Pumps. Specified Model Status = Active, Indoor Type = Mini-Splits, and SEER Min and Max of 13 for 2013 and 2014 and Min and Max of 14 for 2015.
[114] Federal Register Vol 66. No. 14 (2001).
[115] Federal Register Vol 76. No. 123 (2011).
[116] Massachusetts Common Assumption.

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Measure Life

The measure life is 18 years.[118]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Ductless Mini Split HP	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.50

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results and Massachusetts Common Assumptions.[119]

[117] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[118] 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.
[119] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

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HVAC – Central AC Quality Installation Verification (QIV)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The verification of proper charge and airflow during installation of new Central AC system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

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

$$\Delta kW = Tons \times \frac{12\ kBtu/hr}{Ton} \times \frac{1}{EER} \times 5\%$$

Where:

Units	=	Completed QIV
ΔkW	=	Average demand reduction per unit: 0.15 kW (calculated)
ΔkWh	=	Average annual energy reduction per unit: 45 kWh (calculated)
Tons	=	Cooling capacity of AC equipment: Current default is 3 tons [120]
SEER	=	Seasonal efficiency of AC equipment: Default = 14.5
EER	=	Peak efficiency of AC equipment: Default = 12
Hours	=	Equivalent full load hours
5%	=	Average percent demand reduction: 5.0%[121]

Baseline Efficiency

The baseline efficiency case is a cooling system with SEER = 14.5 and EER = 12 whose installation is inconsistent with manufacturer specifications.

[120] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.
[121] Massachusetts Common Assumption.

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High Efficiency

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

Hours

Equivalent full load cooling hours are 360 hours per year.[122]

Measure Life

The measure life is 18 years.[123]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart AC QIV	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results[124].

[122] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[123] 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.
[124] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Heat Pump Quality Installation Verification (QIV)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The verification of proper charge and airflow during installation of new Heat Pump systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{SEER} \times Hours_C + \frac{1}{HSPF} \times Hours_H \right) \times 5\%$$

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

$$\Delta kW_{COOL} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{EER} \right) \times 5\%$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\ kBtu/hr}{Ton} \times \left(\frac{1}{HSPF} \right) \times 5\%$$

Where:

Unit	=	Completed QIV
ΔkW	=	Average demand reduction per unit: 0.22 kW (calculated)
ΔkWh	=	Average annual energy reduction per unit: 308 kWh (calculated)
Tons	=	Cooling capacity of HP equipment: Current default is 3 tons [125]
SEER	=	Seasonal cooling efficiency of HP equipment
EER	=	Peak cooling efficiency of HP equipment
HSPF	=	Heating efficiency of HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating
5%	=	Average demand reduction: 5%[126]

[125] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.
[126] Massachusetts Common Assumption.

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Baseline Efficiency

The baseline efficiency case is a heating and cooling system with SEER = 14.5, EER = 12 and HSPF = 8.2) whose installation is inconsistent with manufacturer specifications.

High Efficiency

The high efficiency case is the same heating and cooling system whose installation is consistent with manufacturer specifications.

Hours

The equivalent full load heating hours are 1,200 hours per year and the equivalent full load cooling hours are 360 hours per year.[127]

Measure Life

The measure life is 18 years.[128]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart HP QIV	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.50

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on Massachusetts Common Assumptions.[129]

[127] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[128] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[129] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and

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HVAC – Central AC Digital Check-up/Tune–up

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Tune-up of an existing central AC system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = Tons \times \frac{12\,kBtu/hr}{Ton} \times \frac{1}{SEER} \times Hours \times 5\%$$

$$\Delta kW = Tons \times \frac{12\,kBtu/hr}{Ton} \times \frac{1}{EER} \times 5\%$$

Where:

Unit	=	Completed tune-up
ΔkWh	=	Average annual energy reduction per unit: 65 kWh (calculated)
ΔkW	=	Average demand reduction per unit: 0.212 kW (calculated)
Tons	=	Cooling capacity of AC equipment: Current default is 3 tons[130]
SEER	=	Seasonal efficiency of AC equipment
EER	=	Peak efficiency of AC equipment
Hours	=	Equivalent full load hours
5%	=	Average demand reduction: 5%[131]

Baseline Efficiency

The baseline efficiency case is a baseline cooling system (SEER = 13 and EER = 11) that does not operate according to manufacturer specifications.

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winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

[130] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.

[131] Massachusetts Common Assumption.

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High Efficiency

The high efficiency case is the same cooling system that operates according to manufacturer specifications.

Hours

The equivalent full load cooling hours are 360 hours per year.[132]

Measure Life

The measure life is 5 years.[133]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart AC Digital Check-up/Tune-up	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on evaluation study results[134].

[132] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[133] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[134] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Heat Pump Digital Check-up/Tune-up

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Tune-up of an existing heat pump system.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = Tons \times \frac{12\,kBtu/hr}{Ton} \times \left(\frac{1}{SEER} \times Hours_C + \frac{1}{HSPF} \times Hours_H \right) \times 5\%$$

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

$$\Delta kW_{COOL} = Tons \times \frac{12\,kBtu/hr}{Ton} \times \left(\frac{1}{EER} \right) \times 5\%$$

$$\Delta kW_{HEAT} = Tons \times \frac{12\,kBtu/hr}{Ton} \times \left(\frac{1}{HSPF} \right) \times 5\%$$

Where:

Unit	=	Completed tune-up
ΔkWh	=	Average annual energy reduction per unit: 373 kWh (calculated)
ΔkW	=	Average demand reduction per unit: 0.257 kW (calculated)
Tons	=	Cooling capacity of HP equipment: Current default is 3 tons[135]
SEER	=	Seasonal cooling efficiency of HP equipment
EER	=	Peak cooling efficiency of HP equipment
HSPF	=	Heating efficiency of HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating
5%	=	Average demand reduction: 5%[136]

[135] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.
[136] Massachusetts Common Assumption.

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Baseline Efficiency

The baseline efficiency case is a system baseline heating and cooling system (SEER = 13, EER = 11 and HSPF = 76) that does not operating according to manufacturer specifications.

High Efficiency

The high efficiency case is the same heating and cooling system that does operate according to manufacturer specifications.

Hours

The equivalent full load hours are 1200 hours per year for heating[137] and 360 hours per year for cooling.[138]

Measure Life

The measure life is 5 years[139]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart HP Digital Check-up/Tune-up	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.50

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results and Massachusetts Common Assumptions.[140]

[137] Massachusetts Common Assumption.
[138] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[139] 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.
[140] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and

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HVAC – Duct Sealing

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: A 66% reduction in duct leakage from 15% to 5% of supplied CFM.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kW$$

Where:
Unit = Completed job
ΔkW = Average demand reduction per unit: 0.300 kW[141]
ΔkWh = Average annual energy reduction per unit: 212 kWh[142]

Baseline Efficiency

The baseline efficiency case is assumes a 15% leakage.

High Efficiency

The high efficiency case is a system with duct leakage reduced by 66% to 5% leakage.

Hours

Not applicable.

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winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.
[141] 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.
[142] Ibid

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Measure Life

The measure life is 18 years.[143]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Sealing	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results[144].

[143] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[144] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Down Size ½ Ton

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Reduction in system size consistent with manual J calculations.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling:

$$\Delta kWh = \Delta kWh/Ton \times ½\ Ton$$
$$\Delta kW = \Delta kW/Ton \times ½\ Ton$$

Where:

Units	=	Completed job
ΔkW/Ton	=	Average demand reduction per ton: 0.295 kW[145]
ΔkWh/Ton	=	Average annual energy reduction per ton: 203 kWh[146]

Baseline Efficiency

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

High Efficiency

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

Hours

Not applicable.

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

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Measure Life

The measure life is 18 years.[147]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Down Size ½ Ton	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results[148].

[147] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[148] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Right Sizing

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Documentation that system size is in compliance with manual J calculations.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kW$$

Where:
Units = completed job
ΔkWh = Average annual energy reduction per unit: 123 kWh[149]
ΔkW = Average demand reduction per unit: 0.150 kW[150]

Baseline Efficiency

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

High Efficiency

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

Hours

Not applicable.

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

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Measure Life

The measure life is 18 years.[151]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Right Sizing Tier 1	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00
Right Sizing Tier 2	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results[152].

[151] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
[152] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Early Replacement of Central AC or Heat Pump Unit

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Early replacement of Central Air Conditioning or Heat Pump Unit. This measure represents the additional savings achieved for the early replacement of existing inefficient AC or heat pump units over the remaining life of the existing equipment.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

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

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

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

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

Where:

Unit	=	Replacement of existing inefficient system with new efficient system
Tons	=	Capacity of AC/HP equipment: Current default is 3 tons[153]
$SEER_{BASE}$	=	Seasonal efficiency of baseline AC equipment
$SEER_{EE}$	=	Seasonal efficiency of new efficient AC equipment
EER_{BASE}	=	Peak efficiency of base AC equipment
EER_{EE}	=	Peak efficiency of new efficient AC equipment
$HSPF_{BASE}$	=	Heating efficiency of baseline HP equipment
$HSPF_{EE}$	=	Heating efficiency of new efficient HP equipment
$Hours_C$	=	EFLH for cooling
$Hours_H$	=	EFLH for heating

[153] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12, Table 4-9.

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Baseline Efficiency

The baseline efficiency case is assumed to be a typical 10-12 year-old central air-conditioning or heat pump unit with SEER 10, EER 8.5, HSPF 7.0.

High Efficiency

For the retirement savings over the remaining life of existing AC unit, the efficient case is a SEER 13, EER 11, HSPF 7.6 unit. For the high efficiency savings over lifetime of the new unit, the efficient case is a new high efficiency SEER 14.5, EER 12, 8.2 HSPF unit.

Year	Measure	EER $_{BASE}$	SEER $_{BASE}$	HSPF $_{BASE}$	EER $_{EE}$	SEER $_{EE}$	HSPF $_{EE}$	ΔkW_C	ΔkW_H	ΔkWh
2013-2015	Early Replacement AC $_{RETIRE}$	8.5	10	n/a	11	13	n/a	0.963	0.000	299
2013-2015	Early Replacement AC $_{EE}$	11	13	n/a	12	14.5	n/a	0.273	0.000	103
2013, 2014	Early Replacement HP_{RETIRE}	8.5	10	7.0	11	13	7.6	0.963	0.406	786
2013, 2014	Early Replacement HP_{EE}	11	13	7.6	12	14.5	8.2	0.273	0.347	519
2015	Early Replacement HP_{RETIRE}	8.5	10	7.0	11.85	14	8.2	1.197	0.753	1,273
2015	Early Replacement HP_{EE}	11.85	14	8.2	12	14.5	8.2	0.038	0.000	32

Hours

The equivalent full load hours are 1,200 hours per year for heating[154] and 360 hours per year for cooling.[155]

Measure Life

The remaining life for the existing unit is 7 years[156], and the measure life of new equipment is 18 years[157]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[154] Massachusetts Common Assumption.
[155] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-5, Table 4-3.
[156] Massachusetts Common Assumption: The early replacement measure life of 7 years was determined by subtracting the estimated target age range of existing equipment between 10 and 12 years old from the 18 year measure life for new equipment.
[157] 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.

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Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Replacement AC	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00
Early Replacement HP	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.50

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results[158] and Massachusetts Common Assumptions. [159]

[158] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.
[159] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the B/C model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

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HVAC – Quality Installation with Duct Modification

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: 50% reduction in duct leakage from 20% to 10%. This measure may also include duct modifications.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on results of DOE2 modeling:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kW$$

Where:

Unit	=	Completed job
ΔkWh	=	Average annual energy reduction per unit: 513 kWh with duct modifications, 212 kWh without duct modifications[160]
ΔkW	=	Average demand reduction per unit: 0.850 kW with duct modifications, 0.300 kW without duct modifications[161]

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.

[160] 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.
[161] Ibid.

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Hours

Not applicable.

Measure Life

The measure life is 18 years.[162]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Energy Star QI	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00
Energy Star QI w/ Duct Modifications	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.25	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation study results[163].

[162] 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.
[163] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation*. Prepared for NSTAR, National Grid, Connecticut Light & Power and United Illuminating; Page 4-12 Table 4-9.

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HVAC – Furnace Fan Motors (ECM)

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of high efficiency motors on residential furnace fans, including electronically commutated variable speed air supply motors.
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas (Residential Heat)
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Installation of high efficiency furnace fan motor
ΔkWh = Average annual energy reduction per unit: 168 kWh[164]
ΔkW = Average demand reduction per unit: 0.124 kW[165]

Baseline Efficiency

The baseline efficiency case is the installation of a furnace with a standard efficiency steady state motor.

High Efficiency

The high efficiency case is the installation of a furnace with an electronically commutated motor.

[164] 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.
[165] Ibid

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Hours

Not applicable.

Measure Life

The measure life is 18 years.[166]

Secondary Energy Impacts

A heating penalty results due to reduced heat loss of the efficient furnace motor.

Measure	Energy Type	ΔMMBtu/Unit[167]
CoolSmart Warm Air Furnace ECM	Natural Gas (Residential Heat)	-0.716

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
CoolSmart Warm Air Furnace ECM	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0. 00	0.16

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based evaluation results[168].

[166] Sachs, Harvey (2003). *Energy Savings from Efficient Furnace Air Handlers in Massachusetts.*
[167] ERS (2011) Pilot Evaluation of BFM DRAFT. Results as of 9/29/2011.
[168] Ibid.

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HVAC – Brushless Fan Motors

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of high efficiency motors on residential furnace fans, including steady state brushless furnace fan motors.
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas (Residential Heat)
Non-Energy Impact: None
Sector: Residential, Low-Income
Market: Lost Opportunity
End Use: HVAC
Program: Residential Cooling & Heating Equipment

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Installation of high efficiency furnace fan motor
ΔkWh = Average annual energy reduction per unit: 246 kWh[169]
ΔkW = Average demand reduction per unit: 0.182 kW[170]

Baseline Efficiency

The baseline efficiency case is the installation of a furnace with a standard efficiency steady state motor.

High Efficiency

The high efficiency case is the installation of a furnace with a brushless fan motor.

Hours

Not applicable.

[169] The Cadmus Group (2012). *Massachusetts Residential Retrofit and Low Income Program Area: Brushless Fan Motors Impact Evaluation.* Prepared for The Electric and Gas Program Administrators of Massachusetts
[170] Ibid.

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Measure Life

The measure life is 9 years.[171]

Secondary Energy Impacts

A heating penalty results due to reduced heat loss of the efficient furnace motor.

Measure	Energy Type	ΔMMBtu/Unit[172]
Brushless Furnace Fan Motor	Natural Gas (Residential Heat)	-0.676

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Brushless Furnace Fan Motor	RHVAC	All	1.00	1.00	1.00	1.00	1.00	0.26	0.25

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are based on evaluation results[173].

[171] Technical lifetime is 18 years but since these are installed on existing furnaces it is reduced to 9 years.
[172] The Cadmus Group (2012). *Massachusetts Residential Retrofit and Low Income Program Area: Brushless Fan Motors Impact Evaluation.* Prepared for The Electric and Gas Program Administrators of Massachusetts June 2012
[173] Ibid.

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HVAC – Room Air Conditioner (Lost Opportunity)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of ENERGY STAR® qualified room air conditioners. ENERGY STAR® qualified air conditioners are typically 10% more efficient than models meeting federal standards.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity, Retrofit
End Use: HVAC
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Rebated room AC unit
ΔkWh	=	Average annual energy savings per unit: 43 kWh[174]
ΔkW	=	Average demand reduction per unit: 0.123 kW[175]

Baseline Efficiency

The baseline efficiency case is a window AC unit that meets the minimum federal efficiency standard for efficiency which currently is EER 9.8.

High Efficiency

The high efficiency level is a room AC unit meeting or exceeding the federal efficiency standard by 10% or more. Average size is 10,000 Btu and average EERs is 10.8.

[174] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner*. Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls.
[175] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Hours

NA

Measure Life

The measure life is 9 years.[176]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Room AC	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[177]

[176] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner.*
[177] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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HVAC – Window AC (Retrofit)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Replacement of existing inefficient room air conditioners with more efficient models. This is only offered as a measure when an AC timer would not reduce usage during the peak period.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (not National Grid)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Replacement of an existing window AC unit with a new efficient window AC unit
ΔkWh = Average annual kWh savings per unit: 204 kWh[178]
ΔkW = Max load kW reduction: 0.582 kW[179]

Baseline Efficiency

The baseline efficiency case is the existing air conditioning unit.

High Efficiency

The high efficiency case is the high efficiency room air conditioning unit.

Hours

Not applicable.

[178] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts..
[179] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 9 years. [180]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Window AC Replacement	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Window AC Replacement	LI MF Retrofit	All (not National Grid)	1.00	1.00	1.00	1.00	1.00	1.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[181]

[180] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner.* Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls.
[181] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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HVAC – Dehumidifiers

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Early retirement of existing dehumidifiers and replacement with high efficiency dehumidifiers
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Lost Opportunity, Retrofit
End Use: HVAC
Program: ENERGY STAR Appliances, Low-Income 1-4 Family Retrofit

Notes

Cape Light Compact is the only PA planning to offer this measure.

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh_{EE} = Capacity \times \frac{0.473}{24} \times \left(\frac{1}{Eff_{BASE}} - \frac{1}{Eff_{EE}} \right) \times Hours$$

$$\Delta kWh_{RETIRE} = Capacity \times \frac{0.473}{24} \times \left(\frac{1}{Eff_{RETIRE}} - \frac{1}{Eff_{BASE}} \right) \times Hours$$

$$\Delta kW_{EE} = \Delta kWh_{EE} \,/\, Hours$$

$$\Delta kW_{RETIRE} = \Delta kWh_{RETIRE} \,/\, Hours$$

Where:

Unit	=	Replacement of existing dehumidifier with new ENERGY STAR® dehumidifier
ΔkWh_{EE}	=	Annual energy savings due to ES unit compared to new baseline unit: 73 kWh
ΔkWh_{RETIRE}	=	Annual energy savings of baseline units compared to existing unit: 34 kWh
ΔkW_{EE}	=	ES replacement demand load savings: 0.042 kW
ΔkW_{RETIRE}	=	Retired demand load savings: 0.020 kW
Capacity	=	Average capacity of dehumidifier in Pints/24 Hours: 35 Pints/Day[182]
Eff_{BASE}	=	Average efficiency of conventional model in Liters/kWh
Eff_{EE}	=	Average efficiency of ENERGY STAR® model in Liters/kWh
Eff_{RETIRE}	=	Average efficiency of existing model in Liters/kWh
Hours	=	Dehumidifier annual operating hours

[182] 35 pints per day was the average turn in at the Cape Light Compact's May 2010 event. This event retired 125 units.

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0.473 = Conversion factor: 0.473 Liters/Pint
24 = Conversion factor: 24 Hours/Day

Baseline Efficiency

The baseline efficiency case for a retired dehumidifier ($Eff_{RETIRED}$) is 1.20 L/kWh[183], which is the pre-EPACT 2005 efficiency for a 35 pint/day unit. The baseline efficiency for an existing unit (Eff_{BASE}) is 1.30 L/kWh[184], which is the current federal standard for a 35 pint/day unit.

High Efficiency

The high efficiency case is an ENERGY STAR® replacement unit with an efficiency of 1.47 L/kWh[185].

Hours

Average annual operating hours are 1,706 hours, calculated as the sum of average operating hours in the summer, winter and spring/fall seasons, where seasonal hours are calculated at the number of days in that season multiplies by the mean operating hours/day.

Season	Mean Hours/Day[186]	% Days in Season[187]	Seasonal Operating Hours
Summer	7.8	25%	712
Winter	2.3	25%	210
Spring/Fall	4.3	50%	785
All	-	-	1,706*

*Cape Light Compact Annual Hours are adjusted by a factor of 1.02 to account for longer operating hours for Cape Light Compact customers compared to customers in other program territories. The adjustment factor represents the weighted average increase in operating hours compared to PA-average hours over all seasons.

Measure Life

The measure life of a replacement unit is 12 years.[188] The remaining measure life of a retired unit is 5 years.[189]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[183] Environmental Protection Agency (2002). *Life Cycle Cost Estimate for ENERGY STAR Dehumidifiers*.
[184] Appliance Standards Awareness Project (2007). *Dehumidifiers*. Website accessed on 6/30/10.
[185] Energy Star Dehumidifiers Product List, posted to the Energy Star website on August 2, 2012.
[186] Opinion Dynamics Corporation (2009). *Massachusetts Residential Saturation Survey (RASS) - Volume 1: Summary Results and Analysis*. Prepared for Cape Light Compact, National Grid, NSTAR Electric, Unitil and Western Massachusetts Electric Company; Page 94, Table 17.
[187] Simplifying assumption.
[188] Environmental Protection Agency (2002). *Life Cycle Cost Estimate for ENERGY STAR Dehumidifiers*.
[189] On average, turn-in units at the Cape Light Compact's May 2010 event were 7 years old. The full measure life of 12 years minus the average age of the retired equipment of 7 years equals a remaining life of 5 years.

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Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Dehumidifiers	ES Appliances	CLC	1.00	1.00	1.00	1.00	1.00	0.85	0. 00
Dehumidifiers	LI 1-4 Retrofit	CLC	1.00	1.00	1.00	1.00	1.00	0.85	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Coincidence factors are based on Massachusetts Common Assumptions.

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HVAC – Thermostats

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Replacement of existing thermostats with programmable thermostats.
Primary Energy Impact: Electric
Secondary Energy Impact: Oil
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Home Energy Services, Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

For electrically heated homes in Home Energy Services unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Electrically-heated household with a programmable thermostat installed
ΔkWh = Average annual kWh reduction: 330 kWh[190]
ΔkW = Average annual kW reduction: 0.176 kW[191]

Baseline Efficiency

The baseline efficiency case is a non-programmable thermostat.

High Efficiency

The high efficiency case is a programmable thermostat.

Hours

Not applicable.

[190] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[191] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators..

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Measure Life

The measure life is 15 years.[192]

Secondary Energy Impacts

For oil heated homes in unit savings are deemed based on study results:

Measure	Program	ΔMMBtu/Unit
Programmable Thermostat (Oil)	HES	3.4[193]
Programmable Thermostat (Oil)	LI 1-4 Retrofit	3.1[194]

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Programmable Thermostat	LI 1-4 Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
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.

[192] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*..
[193] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[194] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.

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HVAC – Boiler Reset Controls

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of weather responsive controls on oil boilers.
Primary Energy Impact: Oil
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Program: Home Energy Services, Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

No electric savings are claimed for this measure.

Baseline Efficiency

The baseline efficiency case has boiler controls installed.

High Efficiency

The high efficiency case includes weather responsive controls installed on the boiler.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[195]

Secondary Energy Impacts

Measure	Program	ΔMMBtu/Unit
Boiler Reset Controls (Oil)	HES	4.7[196]
Boiler Reset Controls (Propane)	HES	4.7[197]

[195] ACEEE (2006). *Emerging Technologies Report: Advanced Boiler Controls*. Prepared for ACEEE; Page 2.
[196] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[197] Ibid.

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Boiler Reset Controls (Oil)	LI 1-4 Retrofit	4.4[198]

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler Reset Controls (Oil)	HES	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Boiler Reset Controls (Oil)	LI 1-4 Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
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.

[198] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.

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HVAC – Weatherization (Electric)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of weatherization measures such as air sealing and insulation in electrically heated homes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Electrically-heated household with weatherization measures installed
ΔkWh = Average annual kWh reduction: 1,616 kWh[199]
ΔkW = Average annual kW reduction: 0.863 kW

Baseline Efficiency

The baseline efficiency case is any existing home shell measures.

High Efficiency

The high efficiency case includes increased weatherization insulation levels.

Hours

Not applicable.

[199] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.

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Measure Life

The measure life is 20 years.[200]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Weatherization (Electric)	LI 1-4 Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[201]

[200] Massachusetts Common Assumption.
[201] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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HVAC – Weatherization (Oil and Other FF)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of weatherization measures such as air sealing and insulation in oil or propane heated homes. Electric savings are achieved from reduced fan run time for heating and cooling systems.
Primary Energy Impact: Oil and Other FF
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Oil or propane heated household with weatherization measures installed
ΔkWh	=	Average annual kWh reduction: 377 kWh[202]
ΔkW	=	Average annual kW reduction: 0.12 kWheat and 0.34 kWcool[203]

Baseline Efficiency

The baseline efficiency case is any existing home shell measures.

High Efficiency

The high efficiency case includes increased weatherization insulation levels.

Hours

Not applicable.

[202] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[203] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 20 years.[204]

Secondary Energy Impacts

Measure	Energy Type	ΔMMBtu/Unit[205]
Weatherization (Oil)	Oil	28.1
Weatherization (Other FF)	Propane	28.1

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Weatherization (Oil and Other FF)	LI 1-4 Retrofit	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 since all PAs programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[206,207]

[204] 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 A-2.
[205] The Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[206] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.
[207] The coincidence factors included in the BC model do not match the coincidence factors that are in the TRM because the BC model only allows for a single max kW reduction to be entered for each measure and the TRM provides separate summer and winter kW reductions for some measures. An adjustment was made to the coincidence factors in the BC model in order to get the model to calculate the correct summer and winter kW reductions.

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HVAC – Heating System Replacement (Oil)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Replacement of existing oil heating system with a new high efficiency system. Electric savings can be attributed to reduced fan run time and reduced usage of electric space heaters.
Primary Energy Impact: Oil
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:

Unit	=	Installation of new high efficiency oil heating system
ΔkWh	=	Average annual kWh savings per unit: 132 kWh[208]
ΔkW	=	Average annual kW reduction per unit: 0.07 kW[209]

Baseline Efficiency

The baseline efficiency case is the existing inefficient heating equipment.

High Efficiency

The high efficiency case is the new efficient heating equipment.

Hours

Not applicable.

[208] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[209] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 18 years.[210]

Secondary Energy Impacts

Measure	Energy Type	ΔMMBtu/Unit
Heating System Replacement (Oil)	Oil	18.4[211]

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Replacement (Oil)	LI 1-4 Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[212]

[210] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*.
[211] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[212] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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HVAC – Early Replacement Boiler

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Early retirement of inefficient oil or propane fired boiler and installation of new high efficiency oil or propane fired boiler.
Primary Energy Impact: Oil, Propane
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings for the early replacement of an existing boiler with a high efficiency boiler are counted in two parts: (1) early retirement savings for a code-compliant boiler compared to the existing boiler over the remaining lifetime of the existing boiler, and (2) efficiency savings for the high efficiency boiler compared to a code-compliant boiler for the full life of the new high efficiency boiler:

$$\Delta MMBtu = \Delta MMBtu_{RETIRE} + \Delta MMBtu_{EE}$$

Where:

	$\Delta MMBtu_{RETIRE}$[213]	$\Delta MMBtu_{EE}$[214]
Oil Forced Hot Water	25.4	8.5
Oil Steam	26.3	3.5
Propane Forced Hot Water	24.0	16.0
Propane Steam	26.3	3.5

Baseline Efficiency

For the retirement savings over the remaining life of existing boiler, the baseline is the existing inefficient boiler estimated to be 65% AFUE. For the high efficiency unit savings over lifetime of the new boiler, the baseline is a code-compliant boiler with an AFUE = 80%.

[213] Calculated using information from GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks
[214] Calculated using information from GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks

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High Efficiency

For the retirement savings over the remaining life of existing boiler, the efficient case is a code-compliant boiler (AFUE = 80%). For the high efficiency savings over lifetime of the new boiler, the efficient case is a new high efficiency (AFUE >= 85% for forced hot water oil, 90% for forced hot water propane and 82% for steam boilers).

Hours

Not applicable.

Measure Life

The remaining life for the existing unit is 10 years[215], and the measure life of new equipment is 20 years.[216]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Replacement Boiler (Retire)	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Early Replacement Boiler (EE)	Residential HEHE	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[215] Agreed upon with EEAC consultants as a reasonable approximation for the number of years an existing boiler would continue to operate if it had not been replaced early due to the program.
[216] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers.*

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Process – Computers

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Rebates for ENERGY STAR® computers.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

Unit savings are based on engineering estimate of delta kW between computers that are idle, in sleep mode, or off:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Rebated ENERGY STAR® desktop computer
ΔkWh = Average annual kWh reduction per unit: See Table 9
ΔkW = Average kW savings per unit: See Table 9

Table 9: Savings for Computers

Tier	ΔkW[217]	ΔkWh[218]
Energy Star Computer	0.015	70
Top Ten Computer	0.017	80

Baseline Efficiency

The baseline efficiency case is a conventional desktop computer.

[217] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[218] Environmental Protection Agency (2012). *ENERGY STAR Desktop & Integrated Computer Product List.* August 2, 2012. Average of all units in category.

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High Efficiency

The high efficiency case is an ENERGY STAR® rated desktop computer including a subset of computers that are both ENERGY STAR® rated and are included in the Top Ten USA ranking.

Hours

The operational hours include: 3,504 annual idle hours, 438 annual sleep hours, and 4,818 annual off hours.[219]

Measure Life

The measure life is 4 years.[220]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Desktop Computers	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1. 00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[221]

[219] ENERGY STAR Program Requirements for Computers Version 5.0
http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Version5.0_Computer_Spec.pdf
[220] Environmental Protection Agency (2012). *Savings Calculator for ENERGY STAR Qualified Office Equipment*
[221] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Process – Pool Pump

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of a 2-speed or variable speed drive pool pump. Operating a pool pump for a longer period of time at a lower wattage can move the same amount of water using significantly less energy.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on the following algorithms which use averaged inputs:

$$\Delta kWh = (kW_{BASE} \times Hours) \times 55\%$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Rebated 2-speed or variable speed pool pump
ΔkWh = Average annual kWh reduction: 400 kWh[222]
ΔkW = Average annual kW reduction: 0.275 kW[223]
Hours = Average annual operating hours of pump
kW_{BASE} = connected kW of baseline pump
55% = average percent energy reduction from switch to 2-speed or variable speed pump[224]

Baseline Efficiency

The baseline efficiency case is a single speed pump.

[222] Estimated using the difference between a Standard Efficiency Single Speed Pump and a Two-Speed with both Speeds Combined * Number of Days in the NE summer season ((13.8 kWh – 9.4 kWh) * 91). Pacific Gas and Electric *The Multi-Speed Pool Pump Fact Sheet.*
[223] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators..
[224] Davis Energy Group (2008). *Proposal Information Template for Residential Pool Pump Measure Revisions*. Prepared for Pacific Gas and Electric Company; Page 2.

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High Efficiency

The high efficiency case is a 2-speed or variable speed pump.

Hours

Hours are considered on a case-by-case basis since they are dependent on seasonal factors, pool size, and treatment conditions.

Measure Life

The measure life is 10 years.[225]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Pool Pumps	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factor
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[226]

[225] Davis Energy Group (2008). *Proposal Information Template for Residential Pool Pump Measure Revisions*. Prepared for Pacific Gas and Electric Company.
[226] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Process – Room Air Cleaner

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Rebates provided for the purchase of an ENERGY STAR® qualified room air cleaner. ENERGY STAR® air cleaners are 40% more energy-efficient than standard models.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed and based on the following algorithms which use averaged inputs:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:

Unit	=	Rebated room air cleaner
ΔkWh	=	Average annual kWh savings per unit: 391 kWh[227]
ΔkW	=	Average connected load reduction: 0.084 kw[228]
Hours	=	Annual operating hours

Baseline Efficiency

The baseline efficiency case is a conventional unit with clean air delivery rate (CADR) of 51-100.

High Efficiency

The high efficiency case is an ENERGY STAR® qualified air cleaner with a CADR of 51-100.

Hours

The savings are based on 16 operating hours per day, 365 days per year.[229]

[227] Environmental Protection Agency (2012), *Savings Calculator for Energy Star Qualified Appliances.*
[228] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[229] Environmental Protection Agency (2012), *Savings Calculator for Energy Star Qualified Appliances.*

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Measure Life

The measure life is 9 years.[230]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Room Air Cleaner	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[231]

[230] Ibid.
[231] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Process – Smart Strips

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Switches off plug load using current sensors and switching devices which turn off plug load when electrical current drops below threshold low levels. Smart Strips can be used on electrical home appliances or in the workplace.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Market: Lost Opportunity, Retrofit
End Use: Process
Program: ENERGY STAR Appliances, Home Energy Services, Low-Income 1-4 Family Retrofit, Multi-Family Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Unit = Rebated smart strip
ΔkWh = Average annual kWh savings per unit: 79 kWh[232]
ΔkW = Max kW savings per unit: 0.017 kW[233]

Baseline Efficiency

The baseline efficiency case is no power strip and leaving peripherals on or using a power surge protector.

High Efficiency

The high efficiency case is a Smart Strip Energy Efficient Power Bar

Hours

Since the power strip is assumed to be plugged in all year, the savings are based on 8,760 operational hours per year.

[232] ECOS 2009 Smart Plug Strips: Draft Report.
[233] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 5 years[234]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Smart Strips	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1. 00
Smart Strips	HES	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Smart Strips	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Smart Strips	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Smart Strips	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[235]
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[234] Massachusetts Common Assumption.
[235] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Process – Televisions

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Rebates for televisions that meet ENERGY STAR® version 5.3 specifications.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Process
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

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

ΔkWh = Average efficient unit annual energy use[236] – Average baseline unit annual energy use[237]
$\Delta kW = \Delta kW$

Where:

Unit	=	Rebated television
ΔkWh	=	Average annual kWh reduction per unit. See Table 10.
ΔkW	=	Average electric demand reduction per unit. See Table 10.

Baseline Efficiency

The baseline efficiency case is a standard television.

High Efficiency

The high efficiency case is an ENERGY STAR® version 5.3 qualified television; including a subset of televisions that are both ENERGY STAR® rated and included in the Top Ten USA ranking. The savings, which are weighted between on and standby modes, for various models are given in Table 10.

[236] Environmental Protection Agency (2012). *ENERGY STAR Television Product List.* June 15, 2012. Average of all units in category.
[237] Environmental Protection Agency (2012). *Savings Calculator for ENERGY STAR Qualified Consumer Electronics.* Energy use of average screen size within category.

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Table 10: Savings for Televisions

Television Size	ΔkW[238]	ΔkWh
Version 5.3 TV <35”	0.019	86.9
Version 5.3 TV >=35”, <50”	0.034	161.2
Version 5.3 TV >=50”	0.061	287.5
Top Ten TV <32”	0.023	105.6
Top Ten TV >=32”, <50”	0.045	212.9
Top Ten TV >=50”	0.072	339.2

Hours

Since the TV is assumed to be plugged in all year, the savings are based on 8,760 operational hours per year. The weighted savings are based on 5 hours on and 19 hours standby each day.

Measure Life

The measure life is 6 years.[239]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Version 5.3 TV <32”	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Version 5.3 TV >=32”, <50”	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Version 5.3 TV >=50”	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Top Ten TV <32”	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Top Ten TV >=32”, <50”	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00
Top Ten TV >=50”	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	0.73	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

[238] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[239] Environmental Protection Agency (2008). Life *Cycle Cost Estimate for ENERGY STAR Television.*

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Coincidence Factors

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[240]

[240] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Refrigeration – Refrigerators (Lost Opportunity)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Rebates for purchase of ENERGY STAR® qualified refrigerators. ENERGY STAR® qualified refrigerators use at least 20% less energy than new, non-qualified models.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential, Low Income
Market: Lost Opportunity
End Use: Refrigeration
Program: ENERGY STAR Appliances, Residential New Construction & Major Renovation, Low-Income Residential New Construction

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = \Delta kWh_{BASE} - \Delta kWh_{ES}$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Installed ENERGY STAR® refrigerator
ΔkWh = Annual savings over non-ES refrigerators averaged by model type: See Table 11
ΔkW = Average kW reduction over non-ES refrigerator: See Table 11

Table 11: Savings for Refrigerators

Tier	ΔkW[241]	ΔkWh[242]
Energy Star Refrigerator	0.013	104
Top Ten Refrigerator	0.019	154

Baseline Efficiency

The baseline efficiency case is a residential refrigerator that meets the Federal minimum standard for energy efficiency.

[241] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[242] Environmental Protection Agency (2012). *Refrigerators Qualified Product List.* July 18, 2012. Average of all units in category.

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High Efficiency

The high efficiency case is an ENERGY STAR® residential refrigerator that uses 20% less energy than models not labeled with the ENERGY STAR® logo, including a subset of refrigerators that are both ENERGY STAR® rated and included in the Top Ten USA ranking.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[243]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Rebate	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93
Refrigerators	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[244]

[243] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator*.
[244] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Refrigeration – Refrigerators (Retrofit)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: This measure covers the replacement of an existing inefficient refrigerator with a new ENERGY STAR® rated refrigerator. ENERGY STAR® qualified refrigerators use at least 20% less energy than non-qualified models.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Refrigeration
Program: Home Energy Services, Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (NSTAR, WMECO)

Algorithms for Calculating Primary Energy Impact

For HES:

Unit savings are deemed based on the following algorithms and averaged inputs:

$$\Delta kWh = \Delta kWh_{RETIRE} + \Delta kWh_{EE}$$
$$\Delta kW = \Delta kW_{RETIRE} + \Delta kW_{EE}$$

Where:

Unit	=	Replacement of existing refrigerator with new ENERGY STAR® Refrigerator
ΔkWh_{RETIRE}	=	Annual energy savings over remaining life of existing equipment: 714 kWh[245]
ΔkWh_{EE}	=	Annual energy savings over full life of new ES refrigerator: 104 kWh[246]
ΔkW_{RETIRE}	=	Average demand reduction over remaining life of existing equipment: 0.086 kW[247]
ΔkW_{EE}	=	Average demand reduction over full life of new ES refrigerator: 0.013 kW[248]

For Low-Income 1-4 Family Retrofit:

Unit savings are deemed based on study results:

[245] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[246] The PAs use the Lost Opportunity savings of 104 kWh as the annual savings over the life of the new ES refrigerator. See *Refrigerator(Lost Opportunity) section.*
[247] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[248] Ibid.

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$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Removal of existing refrigerator and installation of new efficient refrigerator
ΔkWh = Average annual kWh savings per unit: 762 kWh[249]
ΔkW = Max kW Reduction: 0.092 kW[250]

For Low-Income Multifamily Retrofit (NSTAR, WMECO):

Unit savings are deemed based on LI SF study results with an adjustment factor applied:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Removal of existing refrigerator and installation of new efficient refrigerator
ΔkWh = Average annual kWh savings per unit: 645 kWh[251]
ΔkW = Max kW Reduction: 0.092 kW[252]

Baseline Efficiency

For HES:
The baseline efficiency case is an existing refrigerator for savings over the remaining life of existing equipment. The baseline efficiency case is a full-sized refrigerator (7.75 cubic feet) that meets the Federal minimum standard for energy efficiency for savings for the full life.[253]

For Low-Income 1-4 Family Retrofit and Low-Income Multifamily Retrofit:
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 an ENERGY STAR® rated refrigerator that meets the ENERGY STAR® criteria for full-sized refrigerators (7.75 cubic feet), using at least 20% less energy than models meeting the minimum Federal government standard.

[249] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[250] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[251] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts adjusted down by 15.3% because based on historical PA data the average LI MF refrigerator is 84.7% of the size of a LI SF refrigerator.
[252] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[253] Home: ENERGY STAR (2008). *ENERGY STAR Refrigerators & Freezers Key Product Criteria.* http://www.energystar.gov/index.cfm?c=refrig.pr_crit_refrigerators. Accessed 10/11/10.

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Hours

Savings are based on 8,760 operating hours per year.

Measure Life

For HES, and Low-Income Multifamily Retrofit: The remaining life of the existing refrigerator is 1 year, and the measure life for the new refrigerator is 12 years. [254]

For Low-Income 1-4 Family Retrofit: The measure life is 12 years.[255]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerators	HES	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93
Refrigerators	LI MF Retrofit	NSTAR, WMECO	1.00	1.00	1.00	1.00	1.00	1.00	0.86
Refrigerator Replacement	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93

In-Service Rates
In-service rates are 100% as it is assumed all refrigerators are in-use.

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
- HES, MF Retrofit, LI MF Retrofit: Realization rates are based on Massachusetts Common Assumptions.
- LI 1-4 Retrofit: Realization rates are set to 100% since deemed savings are based on evaluation results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[256]

[254] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator.*
[255] Ibid
[256] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Refrigeration – Freezers (Lost Opportunity)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Rebates provided for the purchase of ENERGY STAR® freezers. ENERGY STAR® qualified freezers use at least 10% less energy than new, non-qualified models and return even greater savings compared to old models.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: Refrigeration
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = \Delta kWh_{BASE} - \Delta kWh_{ES}$$
$$\Delta kW = \Delta kWh / 8760 hours$$

Where:
Unit = Installed ENERGY STAR® freezer
ΔkWh = Annual savings over non-ES freezers averaged by model type: See Table 12
ΔkW = Average kW reduction over non-ES freezer: See Table 12

Table 12: Savings for Freezers

Tier	ΔkW[257]	ΔkWh[258]
Energy Star Freezer	0.006	49
Top Ten Freezer	0.017	140

Baseline Efficiency

The baseline efficiency case is a residential freezer that meets the Federal minimum standard for energy efficiency.

[257] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[258] Environmental Protection Agency (2012). *Freezers Qualified Product List.* July 18, 2012. Average of all units in category.

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High Efficiency

The high efficiency case is based on an ENERGY STAR® rated freezer that uses 10% less energy than models not labeled with the ENERGY STAR® logo, including a subset of televisions that are both ENERGY STAR® rated and included in the Top Ten USA ranking.

Hours

Not applicable.

Measure Life

The measure life is 11 years.[259]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Freezer Rebate	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	1.00	0. 93

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[260]

[259] Environmental Protection Agency (2011). *Life Cycle Cost Estimate for ENERGY STAR Freezer*. Accessed 9/7/2011.
[260] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Refrigeration – Freezers (Retrofit)

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: This measure covers the replacement of an existing inefficient freezer with a new energy efficient model.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Refrigeration
Program: Low-Income 1-4 Family Retrofit, Low-Income Multifamily Retrofit (NSTAR, WMECO)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Removal of existing freezer and installation of new efficient freezer
ΔkWh = Average annual kWh savings per unit: 239 kWh[261]
ΔkW = Max kW Reduction: 0.029 kW for LI 1-4 Retrofit and 0.033 for LI MF Retrofit[262]

Baseline Efficiency

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

High Efficiency

The high efficiency case is a new high efficiency freezer.

Hours

Not applicable.

[261] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[262] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 12 years[263]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Freezer Replacement	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93
Freezer Replacement	LI MF Retrofit	NSTAR, WMECO	1.00	1.00	1.00	1.00	1.00	1.00	0.73

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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

Coincidence Factors
Coincidence factors are estimated using the demand allocation methodology described in the Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.[264]

[263] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator*.
[264] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Refrigeration – Refrigerator/Freezer Recycling

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The retirement of old, inefficient secondary refrigerators and freezers.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Refrigeration
Program: ENERGY STAR Appliances

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed and are obtained from the referenced study.

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / 8760$$

Where:
Unit = Removed secondary refrigerator or freezer
ΔkWh = Average annual kWh savings per unit. See Table 13.
ΔkW = Average kW reduction per unit. See Table 13.

Table 13: Savings for Refrigerator/Freezer Recycling

Measure	Program	ΔkW[265]	ΔkWh[266]
Refrigerator Recycle Primary	Energy Star Products	0.064	533
Refrigerator Recycle Secondary Replaced	Energy Star Products	0.084	696
Refrigerator Recycle Secondary Not Replaced	Energy Star Products	0.100	835
Refrigerator Recycle (combined)	Energy Star Products	0.093	755
Freezer Recycle	Energy Star Products	0.080	663

Baseline Efficiency

The baseline efficiency case is an old, inefficient secondary working refrigerator or freezer. Estimated average usage is based on combined weight of freezer energy use and refrigerator energy use.

[265] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[266] NMR Group, Inc. (2011). Massachusetts Appliance Turn-In Program Evaluation Integrated Report Findings – FINAL. Prepared for National Grid, NSTAR Electric, Cape Light Compact, and Western Massachusetts Electric Company.

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High Efficiency

The high efficiency case assumes no replacement of secondary unit.

Hours

Refrigerator and freezer operating hours are 8,760 hours/year.

Measure Life

The measure life is 8 years.[267]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Recycling	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93
Freezer Recycling	ES Appliances	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[268]

[267] Ibid.
[268] The Cadmus Group, Inc. (2012). *Demand Impact Model*. Prepared for the Massachusetts Program Administrators.

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Refrigeration – Appliance Removal

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Removal of second working refrigerator or freezer.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: Refrigeration
Program: Low-Income 1-4 Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Removal of secondary refrigerator or freezer with no replacement
ΔkWh = Average annual kWh savings per unit: 1,180 kWh[269]
ΔkW = Max kW reduction: 0.146 kW [270]

Baseline Efficiency

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

High Efficiency

The high efficiency case assumes no replacement of secondary unit.

Hours

Not applicable.

[269] The Cadmus Group, Inc. (2012). *Low Income Single Family Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[270] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 5 years.[271]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Appliance Removal	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.93

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

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.[272]

[271] Massachusetts Common Assumption.
[272] The Cadmus Group, Inc. (2012). *Demand Impact Model.* Prepared for the Massachusetts Program Administrators.

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Residential New Construction – Heating, Cooling, and DHW Measures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: To capture lost opportunities, encourage the construction of energy-efficient homes, and drive the market to one in which new homes are moving towards net-zero energy.
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas, Oil, Propane
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Lost Opportunity
End Use: HVAC, Hot Water
Program: Residential New Construction & Major Renovation, Low-Income Residential New Construction

Algorithms for Calculating Primary Energy Impact

Savings are derived from three components within this initiative, the Performance Path, the Prescriptive Path, and Hi-Rise Multi-Family building, four stories and higher.

For homes participating in the program via the Performance Path, projected energy use is calculated for each home completed through the program and a geometrically matching baseline home (User Defined Reference Home) using Beacon, an ICF International proprietary DOE-2 based building energy simulation tool. The difference between the projected energy consumption of these two homes represents the energy savings produced by the certified home. This process is used to calculate electric demand as well as electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes, both single family and multifamily for low rise buildings (three stories and below). This process is documented in "Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR® Homes Program."[273]

For homes participating in the program via the Prescriptive Path, deemed savings will be applied to each unit completing the requirements of the program. The deemed savings were derived by ICF International using modeling software to create a sample set of 168 homes that represented every type of home that would typically participate in the initiative, including various building types, sizes, fuel types, HVAC system types and climate locations.[274]

For homes participating in the Hi-Rise Multi-Family portion of the program ICF International created 98 customized engineering formulas for energy conservation measures spanning the following: Domestic Hot Water, Envelope, HVAC, Lighting, Refrigeration/Appliances and Motors & Drives.[275]

[273] ICF International (2008). *Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR ® Homes Program*. Prepared for Joint Management Committee.
[274] ICF International (2012). 2013 Prescriptive Modeling Summary Final
[275] ICF International (2012). Multi-Family Savings Methodology

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Baseline Efficiency

The User Defined Reference Home was revised for 2012 as a result of the baseline study completed in 2012.[276] [277]

High Efficiency

The high efficiency case is represented by the specific energy characteristics of each "as-built" home completed through the program.

Hours

Not applicable.

Measure Life

Measure Type	Measure Life (years)[278]
Cooling	25
Heating	25
Water Heating	15

Secondary Energy Impacts

Gas, Oil and Propane savings for heating and water heating measures are custom calculating using the same methodology described for the electric energy and demand savings.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
ES Homes – Cooling	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
ES Homes – Heating	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
ES Homes – Water Heating	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	1.00	0.94

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

Savings Persistence Factor

[276] NMR Group, Inc., KEMA, Inc., The Cadmus Group, Inc., Dorothy Conant (2012). *Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report*.
[277] NMR Group, Inc., KEMA, Inc., The Cadmus Group, Inc., Dorothy Conant (2012). *Final UDRH Inputs: Addendum to Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report.*
[278] Massachusetts Common Assumption.

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All PAs use 100% savings persistence factors.

Realization Rates

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

Coincidence Factors

Coincidence factors are custom calculated based on project-specific detail.

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Home Energy Services (MassSAVE) – Vendor Measures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Retrofit measures installed through the Home Energy Services (MassSAVE) program including: building envelope insulation and air sealing, duct sealing and insulation.
Primary Energy Impact: Electric
Secondary Energy Impact: Oil, Propane
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Home Energy Services

Notes: The impact evaluation conducted in 2011/2012 on the 2010 program year produced an average deemed savings per home for insulation and air sealing measures. These values are used for planning purposes but reported savings will be based on vendor calculated savings (see below). Additional work is being conducted in late 2012/early 2013 to develop realization rates that would be applied to the vendor estimate savings. The 2012 Report Version of the TRM will include these realization rates.

Algorithms for Calculating Primary Energy Impact

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

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

The PAs calculate demand (kW) savings by applying a kW/kWh factor to the vendor-estimated electric energy savings. The kW/kWh factors are provided in Table 14.

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Table 14: kW Factors for HES Vendor Measures

Measure	kW/kWh Factor[279]
Air Sealing (Electric)	0.00053
Air Sealing (Gas, Oil, Other FF)	0.00222
Duct Insulation (Electric)	0.00053
Duct Insulation (Gas, Oil, Other FF)	0.00222
Duct Sealing (Electric)	0.00053
Duct Sealing (Gas, Oil, Other FF)	0.00222
Insulation (Electric)	0.00053
Insulation (Gas, Oil, Other FF)	0.00222

Table 15: Deemed kWh Savings Used for Planning

Measure	ΔkWh[280]
Air Sealing	710
Insulation (overall)	903
Attic Insulation	793
Wall Insulation	972
Basement Insulation	99
Duct Insulation	1,613
Duct Sealing	428

Baseline Efficiency

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

High Efficiency

The high efficiency case includes installed energy efficiency measures that reduce heating, cooling and water heating energy use.

Hours

Hours are project-specific.

[279] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. For electric measures the heating loadshape was used for non-electric the central AC loadshape was used.
[280] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.

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Measure Life

Table 16: Measure Lives for HES Vendor Measures

Measure Name	Measure Life (years)
Air Sealing	15
Duct Insulation	20
Duct Sealing	20
Insulation	25

Secondary Energy Impacts

Oil and Propane savings are project-specific and estimated by the program vendors as described above.

Table 17: Deemed MMBtu Savings Used for Planning

Measure	ΔOil MMBtu[281]	ΔPropane MMBtu[282]
Air Sealing	5.6	5.3
Insulation (overall)	12.2	9.6
Attic Insulation	9.2	7.7
Wall Insulation	11.8	9.9
Basement Insulation	1.4	1.4
Duct Insulation	7.7	6.8
Duct Sealing	4.1	3.6

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[281] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[282] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts. Gas savings used as an estimate for propane savings.

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Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Air Sealing (Electric)	HES	All	1.00	1.00	1.00	1.00	1.00	0.0	1.00
Air Sealing (Gas, Oil, Other FF)	HES	All	1.00	1.00	1.00	1.00	1.00	1.0	0.00
Duct Insulation (Electric)	HES	All	1.00	1.00	1.00	1.00	1.00	0.0	1.00
Duct Insulation (Gas, Oil, Other FF)	HES	All	1.00	1.00	1.00	1.00	1.00	1.0	0.00
Duct Sealing (Electric)	HES	All	1.00	1.00	1.00	1.00	1.00	0.0	1.00
Duct Sealing (Gas, Oil, Other FF)	HES	All	1.00	1.00	1.00	1.00	1.00	1.0	0.00
Insulation (Electric)	HES	All	1.00	1.00	1.00	1.00	1.00	0.0	1.00
Insulation (Gas, Oil, Other FF)	HES	All	1.00	1.00	1.00	1.00	1.00	1.0	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are based on Massachusetts Common Assumptions.

Coincidence Factor
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[283]

[283] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Vendor Calculated Savings (NSTAR)

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Retrofit measures installed through the Low Income Multifamily program including: weatherization and interior/exterior common area fixtures.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC, Lighting
Program: Low-Income Multifamily Retrofit (NSTAR)

Algorithms for Calculating Primary Energy Impact

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

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. 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.

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Multifamily –Insulation (Attic, Basement, Wall)

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Insulation upgrades are applied in existing facilities.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Electric Heating Savings:

$$kWh_{annual} = \frac{\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) \times HDD \times 24 \times Area}{1{,}000{,}000 \times \eta_{heat}} \times 293.1$$

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

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

ΔkWh= *Annual kWh cooling savings + Annual kWh electric heating savings*
$\Delta kWcooling = \Delta kWhcooling \times kW / kWhcooling$
$\Delta kWheating = \Delta kWhheating \times kW / kWhheating$

Where:

R_{exist}	=	Existing effective R-value (R-ExistingInsulation + R-Assembly), ft^2-°F/Btuh
R_{new}	=	New total effective R-value (R-ProposedMeasure + R-ExistingInsulation + R-Assembly), ft^2-°F/Btuh
DUA	=	Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F = 0.75[284]

[284] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.

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Area	=	Square footage of insulated area
η_{cool}	=	Efficiency of Air Conditioning equipment (SEER or EER)
η_{heat}	=	Efficiency of the heating system (AFUE or COP)
293.1	=	Conversion constant (1MMBtu = 293.1 kWh)
24	=	Conversion for hours per day
CDH	=	Cooling Degree Hours; dependent on location, see table below
HDD	=	Heating Degree Days; dependent on location, see table below
1,000,000	=	Conversion from Btu to MMBtu
kW/kWh cooling	=	Average annual kW reduction per kWh reduction: 0.00222 kW/kWh[285]
kW/kWh heating	=	Average annual kW reduction per kWh reduction: 0.00050 kW/kWh[286]

HDD Values by Weather Station[287]

TMY3 City	HDD	CDH
Barnstable Muni Boa	4379	1349
Beverly Muni	5329	3432
Boston Logan Int'l Arpt	4550	4329
Chicopee Falls Westo	5016	4116
Lawrence Muni	4640	3978
Marthas Vineyard	4312	1345
Nantucket Memorial AP	3988	362
New Bedford Rgnl	4434	4232
North Adams	5234	2524
Norwood Memorial	4872	4763
Otis ANGBb	4718	2588
Plymouth Municipal	4559	2138
Provincetown (AWOS)	4368	2195
Westfield Barnes Muni AP	5301	3784
Worchester Regional Arpt	5816	1753

Baseline Efficiency

The baseline efficiency case is the R-value of the existing insulation.

High Efficiency

The high efficiency case is insulation installed with a higher R-Value.

Hours

Not applicable.

Measure Life

The measure life is 25 years.[288]

[285] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Cooling (UNIT_CENTRAL_AC) Normal
[286] Ibid. Loadshape: Res Multi Family Electric Heating (UNIT_CENTRAL_HEAT) Normal
[287] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.

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Secondary Energy Impacts

There are no secondary energy impacts for this measure

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation (cooling)	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Insulation (cooling)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Insulation (heating)	MF Retrofit,	All	1.00	1.00	1.00	1.00	1.00	0.01	1.00
Insulation (heating)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.01	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model.[289]

[288] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[289] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily –Showerheads

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: The measure involves the replacement of an existing showerhead with the baseline flow rate between 3.5 and 3.3 GPM, with a low flow showerhead having a maximum flow rate of 2.5 GPM.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Unit	=	Showerhead
ΔkWh	=	Average annual kWh reduction per unit: 129 kWh[290]
kW/kWh	=	Average kW reduction per kWh reduction: 0.00017 kW/kWh[291]

Baseline Efficiency

The baseline efficiency case is an existing shower head with a high flow.

High Efficiency

High efficiency is a low flow showerhead.

Hours

Not applicable.

[290] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[291] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Water Heat (UNIT_WATER_HEAT) Normal

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Measure Life

The measure life is 7 years.[292]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Benefits

Benefit Type	Description	Savings
Residential Water	Gallons water saved per year per unit that received DHW measures[293]	3,696 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Showerhead	MF Retrofit	All	1.00	0.93	1.00	1.00	1.00	0.58	1.00
Showerhead	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.58	1.00

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

Savings Persistence Factor
Savings Persistence Factors for MF Retrofit are from the 2011 Residential Retrofit Multifamily Impact Analysis[294]

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model[295].

[292] Massachusetts Common Assumption.
[293] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators
[294] The Cadmus Group, Inc. (2012). *Massachusetts 2011Residential Retrofit Multifamily Program Analysis*. Prepared for the Massachusetts Program Administrators
[295] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily –Faucet Aerators

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: The measure involves the replacement of existing aerator being replaced with a low flow aerator having a maximum flow rate of 1.5 GPM.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water **Sector:** Residential, Low Income
Market: Retrofit
End Use: Hot Water
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Unit	=	Faucet aerator
ΔkWh	=	Average annual kWh reduction per unit: 97 kWh[296]
kW/kWh	=	Average kW reduction per kWh reduction: 0.00017 kW/kWh[297]

Baseline Efficiency

The baseline efficiency case is an existing faucet aerator with a high flow.

High Efficiency

High efficiency is a low flow faucet aerator.

Hours

Not applicable.

[296] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[297] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Water Heat (UNIT_WATER_HEAT) Normal

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Measure Life

The measure life is 7 years.[298]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Benefits

Benefit Type	Description	Savings
Residential Water	Gallons water saved per year per unit that received DHW measures[299]	332 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Aerator	MF Retrofit	All	1.00	0.96	1.00	1.00	1.00	0.58	1.00
Aerator	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.58	1.00

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

Savings Persistence Factor
Savings Persistence Factors for MF Retrofit are from the 2011 Residential Retrofit Multifamily Impact Analysis[300]

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model[301].

[298] Massachusetts Common Assumption.
[299] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators
[300] The Cadmus Group, Inc. (2012). *Massachusetts 2011Residential Retrofit Multifamily Program Analysis*. Prepared for the Massachusetts Program Administrators
[301] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – DHW Tank Wrap

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: This measure relates to a Tank Wrap or insulation "blanket" that is wrapped around the outside of an electric *storage water heater* to reduce stand-by losses.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

Unit	=	Each installation for tank wraps.
kWh	=	Average annual kWh reduction per unit: 73 kWh[302]
kW/kWh	=	Average annual kW reduction per kWh reduction: 0.00017 kW/kWh[303]

Baseline Efficiency

The baseline efficiency case is no wrap on the tank.

High Efficiency

High efficiency is the addition of a tank wrap.

Hours

Not applicable.

[302] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[303] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Water Heat (UNIT_WATER_HEAT) Normal

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Measure Life

The measure life is 7 years.[304]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Tank/Pipe Wrap	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.58	1.00
Tank/Pipe Wrap	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.58	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[305]

[304] Massachusetts Common Assumption.
[305] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – DHW Pipe Wrap

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: This measure describes adding insulation to un-insulated copper electric domestic hot water pipes. The measure assumes the pipe wrap is installed on the exposed hot water pipes and the first 5 feet of the cold water pipes.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

Unit	=	Each installation for pipe wrap.
kWh	=	Average annual kWh reduction per unit: 129 kWh[306]
kW/kWh	=	Average annual kW reduction per kWh reduction: 0.00017 kW/kWh[307]

Baseline Efficiency

The baseline efficiency case is no wrap on the pipe.

High Efficiency

High efficiency is the addition of a pipe wrap.

Hours

Not applicable.

[306] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[307] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Water Heat (UNIT_WATER_HEAT) Normal

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Measure Life

The measure life is 7 years.[308]

Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Tank/Pipe Wrap (Electric)	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.58	1.00
Tank/Pipe Wrap (Electric)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.58	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[309]

[308] Massachusetts Common Assumption.
[309] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Programmable Thermostats

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of programmable thermostats
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (kWh_{cool} + kWh_{heat}) \times \%savings$$
$$\Delta kW = \Delta kW$$

kWh_{cool} = Average kWh consumption of the air conditioning system[310]
kWh_{heat} = Average kWh consumption of the electric resistance[311]
%savings = Energy savings percent from installation of programmable thermostats, deemed at 6.2%.[312]

Deemed Annual Savings

System Type	Space Heating UEC	Cooling UEC	Annual Savings (6.2%)
Electric Resistance, No AC	4140	0	257
Electric Resistance, with AC	4140	397	281
Heat Pump	3292	594	241
AC-Only	0	397	25

System Type	ΔkW[313]
Electric Resistance, No AC	0.128
Electric Resistance, with AC	0.128
Heat Pump	0.101
AC-Only	0.056

[310] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[311] Ibid.
[312] Ibid.
[313] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Baseline Efficiency

The baseline efficiency case is a system without a set back programmable thermostat.

High Efficiency

The high efficiency case is a system with a set-back programmable and fixed set point (common areas) thermostats.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[314]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Programmable Thermostat (Electric Resistance, No AC)	MF Retrofit	All	1.00	0.69	1.00	1.00	1.00	0.01	1.00
Programmable Thermostat (Electric Resistance, No AC)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.01	1.00
Programmable Thermostat (Electric Resistance, with AC)	MF Retrofit	All	1.00	0.69	1.00	1.00	1.00	0.41	1.00
Programmable Thermostat (Electric Resistance, with AC)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.41	1.00
Programmable Thermostat (Heat Pump)	MF Retrofit	All	1.00	0.69	1.00	1.00	1.00	0.81	1.00
Programmable Thermostat (Heat Pump)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.81	1.00
Programmable Thermostat (AC-Only)	MF Retrofit	All	1.00	0.69	1.00	1.00	1.00	1.00	0.00
Programmable Thermostat (AC-Only)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	1.00	0.00

[314] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*.

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

Savings Persistence Factor
Savings persistence factor for MF Retrofit is from an evaluation study.[315]

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model[316].

[315] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[316] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Heat Pump Tune-Up

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: This measure involves the tune-up of an existing split system air-source Heat Pump for both common area and dwelling units in Multi-family applications.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:
$\Delta kWh_{dwelling}$ = Average annual kWh reduction for systems that treat dwelling units: 180 kWh[317]
ΔkWh_{common} = Average annual kWh reduction for systems that treat common areas: 325 kWh[318]
kW/kWh = Average kW reduction per kWh reduction: 0.00056 kW/kWh[319]

Baseline Efficiency

The baseline efficiency case is an existing heat pump that is not tuned up.

High Efficiency

The high efficiency case is an existing heat pump that is tuned up.

Hours

Not applicable.

[317] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[318] Ibid.
[319] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Measure Life

The measure life is 5 years.[320]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Pump Tune-up	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.32	1.00
Heat Pump Tune-up	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.32	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[321]

[320] Massachusetts Common Assumption.
[321] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Air Sealing

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \frac{Vol \times \Delta ACH \times 0.018 \times HDD \times \frac{24}{\eta_{heating}}}{3413}$$

$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

Vol	=	[ft3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
ΔACH	=	[ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)
HDD60	=	Heating degree-days, base 60 from TMY3 weather data. See table below.
ηheating	=	[AFUE, COP, thermal efficiency(%)] Efficiency of the heating system, as determined on site (Auditor Input)
24	=	Conversion factor: 24 hours per day
0.018	=	[Btu/ft3- ºF] Air heat capacity: The specific heat of air (0.24 Btu/ºF.lb) times the density of air (0.075 lb/ft3)
3413	=	Conversion factor: 3413 Btu/kWh

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kW/kWh = Average kW reduction per kWh reduction: 0.00050 kW/kWh[322]

HDD Values by Weather Station[323]

TMY3 City	HDD	CDH
Barnstable Muni Boa	4379	1349
Beverly Muni	5329	3432
Boston Logan Int'l Arpt	4550	4329
Chicopee Falls Westo	5016	4116
Lawrence Muni	4640	3978
Marthas Vineyard	4312	1345
Nantucket Memorial AP	3988	362
New Bedford Rgnl	4434	4232
North Adams	5234	2524
Norwood Memorial	4872	4763
Otis ANGBb	4718	2588
Plymouth Municipal	4559	2138
Provincetown (AWOS)	4368	2195
Westfield Barnes Muni AP	5301	3784
Worchester Regional Arpt	5816	1753

Baseline Efficiency

The baseline efficiency case is a facility that has not received comprehensive air-sealing treatment.

High Efficiency

The high efficiency case is a facility with thermal shell air leaks that are sealed, leading to a reduction in air leakage.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[324]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[322] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[323] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[324] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

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Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Air Sealing (Electric)	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.01	1.00
Air Sealing (Electric)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	0.01	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[325]

[325] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Window AC Replacement

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Removal of old inefficient window air conditioner with the installation of new efficient window air conditioner.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income Multifamily Retrofit (National Grid Only)

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions

$\Delta kWh = (Capacity_{existing} / EER_{existing} - Capacity_{new}/EER_{new}) * hours/1000$

$\Delta kW = (Capacity_{exisitng}/EER_{existing} - Capacity_{new}/EER_{new}) /1000$

Where:
$Capacity_{exisitng}$ = size of existing unit in BTUs/hour
$Capacity_{new}$ = size of new unit in BTUs/hour
$EER_{exisitng}$ = Energy Efficiency Ratio of base AC equipment
EER_{new} = Energy Efficiency Ratio of new efficient AC equipment
Hours = Equivalent full load hours= 200

Baseline Efficiency

The baseline efficiency case is the existing air conditioning unit.

High Efficiency

The high efficiency case is the high efficiency room air conditioning unit.

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Hours

Equivalent full load hours are 200 hours per year.[326]

Measure Life

The measure life is 9 years.[327]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Window AC Replacement	MF LI Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	0.0

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer coincidence factor is equal to 1 because due to program requirements this measure can only be installed if it is used during the peak period.

[326] 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.
[327] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner.*

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Multifamily – Refrigerators and Freezers

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Refrigeration
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \left[\left(\left(kWh_{pre} - kWh_{std}\right)\right) \times \frac{(12-8)}{12} + \left(\left(kWh_{std} - kWh_{ES}\right)\right) \times \frac{8}{12}\right] \times F_{occ}$$

$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

kWh_{pre}	=	Annual kWh consumption of existing equipment. Value is based on metering or AHAM database
kWh_{std}	=	Annual kWh consumption of a refrigerator meeting federal standards. Calculated by dividing the kWh_{ES} by 0.8 (i.e., the Energy Star units are assumed to be 20% more efficient than the kWh_{std} units).
kWh_{ES}	=	Annual kWh consumption of new Energy Star qualified refrigerator or freezer. This is from the nameplate on the new unit.
Age	=	Age of the existing refrigerator is 8 years
12	=	Measure life for a new refrigerator[328]
Focc	=	Occupant adjustment factor used to adjust the energy savings according to the number of occupants in the dwelling unit. See Table below
kW/kWh	=	Average kW reduction per kWh reduction: 0.00013 kW/kWh[329]

[328] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator.*
[329] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Refrigeration (REFRIGERATOR) Normal

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Occupant Adjustment Factor[330]

Number of Occupants	F_{occ}
0 occupants	1.00
1 occupants	1.05
1.8 occupants	1.09
2 occupants	1.10
3 occupants	1.13
4 occupants	1.15
5 occupants	1.16

Baseline Efficiency

The baseline efficiency case is an existing refrigerator for which the annual kWh may be looked up in a refrigerator database. If the manufacturer and model number are not found, the refrigerator is metered for 1.5 hours in order to determine the annual kWh.

High Efficiency

The high efficiency case is a new more efficiency refrigerator. The manufacture and model number is looked up in a refrigerator database to determine annual kWh.

Measure Life

The measure life is 12 years[331].

Hours

Not applicable.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[330] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for the Massachusetts Electric and Gas Program Administrators.
[331] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator.*

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Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrig/Freezers (Electric)	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.86
Refrig/Freezers (Electric)	LI MF Retrofit	NGRID, Unitil, CLC	1.00	1.00	1.00	1.00	1.00	1.00	0.86

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[332]

[332] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Fixtures and CFLs

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Removal of existing inefficient fixtures/bulbs with the installation of new efficient fixtures/bulbs
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: Lighting
Program: Multi-Family Retrofit, Low-Income Multifamily Retrofit (National Grid, Unitil, CLC)

Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = \left[\left(QTY_{PRE} \times Watts_{PRE} \times Hours_{PRE}\right) - \left(QTY_{EE} \times Watts_{EE} \times Hours_{EE}\right)\right] / 1000 \times 52$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

QTY_{PRE}	=	Quantity of pre-retrofit fixtures/bulbs
QTY_{EE}	=	Quantity of efficient fixtures/bulbs installed
$Watts_{PRE}$	=	Rated watts of pre-retrofit fixtures/bulbs
$Watts_{EE}$	=	Rated watts of efficient fixtures/bulbs installed
$Hours_{PRE}$	=	Weekly hours of operation for pre-retrofit case lighting fixtures/bulbs
$Hours_{EE}$	=	Weekly hours of operation for efficient lighting fixtures/bulbs
52	=	Weeks per year
kW/kWh	=	Average kW reduction per kWh reduction: 0.00030 kW/kWh[333]

Baseline Efficiency

The baseline efficiency case is the existing fixture and bulbs.

High Efficiency

The high efficiency case is the new fixture and lamps.

[333] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Lighting - Indoor (LIGHTING) Normal

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Measure Life[334]

	2013	2014	2015
CFLs	6	6	6
Indoor Fixtures	11	12	12
Outdoor Fixtures	6	6	6
LED lamp	12	13	13
LED Fixture	12	13	13

Hours

Operating hours are estimated by the vendor for each facility. Typical assumptions are 24 hours/day for common area lighting, 12 hours/day for exterior lighting, and 3 hours/day for in-unit lighting, but may be adjusted based on type of housing. Estimates are verified with facility maintenance staff when possible.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Indoor Fixtures and CFLs	MF Retrofit	All	0.97	0.99	1.00	1.00	1.00	0.17	1. 00
Outdoor Fixtures and CFLs	MF Retrofit	All	0.97	0.99	1.00	1.00	1.00	0.00	1.00
Indoor Fixtures and CFLs	LI MF Retrofit	NGRID, Unitil	1.00	1.00	1.00	1.00	1.00	0.17	1. 00
Outdoor Fixtures and CFLs	LI MF Retrofit	NGRID, Unitil	1.00	1.00	1.00	1.00	1.00	0.00	1.00

In-Service Rates
In service rate for MF Retrofit is from an evaluation study.[335]

Savings Persistence Factor
Savings persistence factor for MF Retrofit is from an evaluation study.[336]

[334] The adjusted measure life accounts for changes in the baseline due to EISA standards as shown in the MA Lighting Worksheet
[335] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis*. Prepared for the Massachusetts Electric and Gas Program Administrators.
[336] Ibid.

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Realization Rates

Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors

Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[337]

[337] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily – Occupancy Sensors

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: The installation of occupancy sensors for lighting fixtures. This measure involves installing an occupancy sensor that controls lighting fixtures and limits their use when the space is unoccupied
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Lighting
Program: Multi-Family Retrofit, Low Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithms which use averaged inputs[338]:

$$\Delta kWh = \frac{(Watts_{controlled}) \times Hrs \times svg}{1{,}000}$$

Where:

Watts controlled	=	Connected load wattage controlled by Occupancy Sensor
Hours	=	Assumed run time of fixture (before the installation of occupancy sensors (Auditor Input)
svg	=	Percentage of annual lighting energy saved by occupancy sensor is 30%[339]

Baseline Efficiency

The baseline condition for this measure is a lighting fixture that is not controlled by an occupancy sensor.

High Efficiency

The high efficiency case is a lighting fixture that operates with connected occupancy sensors.

Hours

Deemed values for hours may be used if auditor does not collect information.

[338] The Cadmus Group, Inc. (2012). *Massachusetts Multifamily Program Impact Analysis*. Prepared for the Electric and Gas Program Administrators of Massachusetts.
[339] Ibid.

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Zone	Usage Category	Hours/Day (Calc.)[340]
Common Area (Exterior)	Exterior	10.3
Common Area (Interior)	Extended Hours & 24/7	24.0
Common Area (Interior)	Low Usage	3.4
Common Area (Interior)	Medium Usage	12.5
Common Area (Interior)	Non-Area Specific	16.2
Dwelling Unit	Unit	2.6

Measure Life

The measure life is 10 years.[341]

Secondary-Energy Impacts

There are no secondary energy impacts counted for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Common Area Occupancy Sensors	MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00
Common Area Occupancy Sensors	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off- peak periods.

[340] Ibid.
[341] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

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Multifamily - Lighting Bi-Level Stairwell Controls

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: The installation of bi-level stairwell lighting controls in a MF building. Energy savings are achieved by reducing the annual operating hours of the connected lighting fixtures. In most cases, regulations allow lamps to be dimmed to as low as 5% of normal illumination. Building code requirements prohibit zero light levels, even when unoccupied.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: Lighting controls
Program: Low-Income Multi-Family Retrofit

Algorithms for Calculating Primary Energy Impact

Savings are based on the following algorithms:

Annual kWh Savings= Watts (fixture) x 8760 /1000 x SF[342]
$\Delta kW = \Delta kWh \times kW / kWh$

Where:
Watts(fixture) = Total fixture wattage being controlled
8760 = Hours per year
1000 = kilowatt adjustment
SF = Savings factor, in this case the proposed savings is 45%[343]
kW/kWh = 0.00030[344]

Most common stairwell fixtures are either (1 or 2)-lamp 40 W T12 fixtures or (1 or 2)-lamp 32 W T8 bi-level lighting fixtures. Average kWh savings given these fixtures is 171.48.

Baseline Efficiency

The baseline efficiency case is a lighting fixture that operates without controls.

[342] Cadmus Group, Massachusetts Low-Income Measure Assessment
[343] Ibid.
[344] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Lighting - Indoor (LIGHTING) Normal

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High Efficiency

The high efficiency case is a lighting fixture that operates with connected bi-level stairwell controls.

Hours

The average annual operating hours before the measure installation is 3,000 hours per year.[345]

Measure Life

The measure life is 12 years.[346]

Secondary-Energy Impacts

There are no secondary energy impacts counted for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Bi-level Stairwell Controls	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.17	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[347]

[345] Ibid; assumption from the Lighting Fixture Basis formula.
[346] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[347] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Multifamily - Exterior Photocell

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: The installation of a low voltage exterior photocell that automatically turns lighting on and off.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Retrofit
End Use: Lighting
Program: Low Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are based on the following algorithms which use averaged inputs[348]:

$$\Delta kWh = ((kW \times n \times Hours)*110\%) - (kW \times n \times Hours)$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

Unit	=	Rebated exterior photocell
ΔkWh	=	Annual energy savings: 210 kWh
kW	=	Wattage of light: 240/1000[349]
Hours	=	Hours of use with photocell: 4,380
n	=	Quantity of fixtures: 2 fixture[350]
kW/kWh	=	0.00031[351]

Baseline Efficiency

The baseline efficiency case is a manually-controlled exterior 240 watt lighting fixture in a multifamily building.

[348] The Cadmus Group, Inc. Mass SAVE Low Income Measure Assessment. *MA LI Measure Assessment_07112.xls*. 'Photocell' worksheet, based on Multifamily savings
[349] Ibid.
[350] Ibid.
[351] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators. Loadshape: Res Multi Family Electric Lighting - Outdoor (LIGHTING) Normal

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High Efficiency

The high-efficiency case is an exterior lighting fixture that operates with a connected exterior photocell.

Hours

The average annual operating hours before the measure installation is 4,380 hours per year.[352]

Measure Life

The measure life is 10 years.[353]

Secondary-Energy Impacts

There are no secondary energy impacts counted for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
MF Exterior Photocell	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off- peak periods.

[352] Ibid.
[353] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

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Multifamily - Clothes Washers

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: The installation of an ENERGY STAR® clothes washer with minimum Modified Energy Factor (MEF) of 2.0, Water Factor (WF) of 6.0 with an electric dryer and a gas or electric water heater. ENERGY STAR® clothes washers are on average, 30% more energy-efficient than non-qualified models, and are more efficient than models that simply meet the federal minimum standard for energy efficiency. ENERGY STAR® qualified clothes washers use half the amount of water used by regular washers.[354]
Primary Energy Impact: Electric
Secondary Energy Impact: Natural Gas
Non-Energy Impact: Residential Water, Low-Income Annual Discounted Rate Cost Reduction
Sector: Residential
Market: Lost Opportunity
End Use: Hot Water
Program: Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on Energy Star calculations:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW$$

Where:
Unit = Installation of ENERGY STAR® clothes washer
ΔkWh = Average annual energy reduction per unit: 1,218 kWh per year with electric water heating and 1,054 kWh with gas water heating; [355]
ΔkW = Average demand reduction per unit: 0.186 kW with electric water heating and 0.161 kW for gas water heating[356]

Baseline Efficiency

The baseline efficiency case is a conventional standard sized non-ENERGY STAR® qualified model meeting Federal Standards energy performance metric criteria of effective January 1, 2011 for clothes washers with a MEF of 1.26 or greater as well as a WF of 9.5 or lower.[357]

[354] Home: ENERGY STAR (2012). *Clothes Washers*. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw. Accessed on 8/2/12.
[355] ENERGY STAR; DOE Federal Test Procedure 10 CFR 430, Appendix J1 and Multi-family Laundry Association, 2002 and Cadmus CPUC Clothes Washers Study.
[356] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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High Efficiency

The high efficiency case is an ENERGY STAR® qualified clothes washer meeting the energy performance metric criteria effective January 1, 2011 for clothes washers with a MEF of 2.0 or greater as well as a WF of 6.0 or lower.

Measure Life

The measure life is 11 years.[358]

Secondary Energy Impacts

Gas savings occur in homes where the water is heated by that fuel.

Measure	Energy Type	ΔMMBtu/Unit[359]
Clothes washers (Gas)	NG – Residential DHW	0.75

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Reduction in annual water usage compared to conventional unit [360]	15,813 Gallons/Unit
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Clothes washers	LI MF Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.90

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are set to 100% since this program has not been evaluated.

Coincidence Factors

[357] Home: ENERGY STAR (2012). *Clothes Washers Key Product Criteria*. http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers. Accessed on 8/2/12.
[358] ENERGY STAR; Appliance Magazine, September 2008.
[359] Northwest Power Planning Council. Regional Technical Forum. http://www.nwcouncil.org/energy/rtf/measures. "ResClothesWashersSF_FY10v2_0.xls", *Assumptions*, Water Heating Use Input Assumptions from FY10 analysis. Gas Water Heater Recovery Efficiency.
[360] ENERGY STAR Calculated from www.energystar.gov. Qualified Clothes Washers. res_clothes_washers.xls. Posted July 2009.

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Summer and winter coincidence factors are estimated using demand allocation methodology described in the Cadmus Demand Impact Model.[361]

[361] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.

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Custom Measures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of complex custom energy efficiency measures including solar hot water installations and fuel switching projects.
Primary Energy Impact: Electric
Secondary Energy Impact: Project-specific
Non-Energy Impact: Project-specific
Sector: Residential, Low Income
Market: Lost Opportunity, Retrofit
End Use: All
Program: All

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

The baseline efficiency case for Lost Opportunity projects assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice. The baseline efficiency case for retrofit projects is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency case is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined based on specific project using the common measure life recommendations.

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Secondary Energy Impacts

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

Non-Energy Impacts

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

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Solar DHW	HES	All	1.00	1.00	1.00	1.00	1.00	custom	custom
Solar DHW	LI 1-4 Retrofit	All	1.00	1.00	1.00	1.00	1.00	custom	custom
Fuel Switching	HES	All	1.00	1.00	1.00	1.00	1.00	custom	custom

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
Realization rates are set to zero since project savings estimates are based on project-specific detail.

Coincidence Factors
Coincidence factors for summer and winter peak periods are custom-calculated based on project-specific detail.

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Commercial and Industrial Electric Efficiency Measures

Lighting – Advanced Lighting Design (Performance Lighting)

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Advanced lighting design refers to the implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction situation. Advanced lighting design uses techniques like maximizing task lighting and efficient fixtures to create a system of optimal energy efficiency and functionality.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: O&M
Sector: Commercial and Industrial
Market: Lost Opportunity
End Use: Lighting
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \sum_{i=1}^{n}\left(\frac{LPD_{BASE,i} \times Area_i \times Hours_i}{1000}\right) - \sum_{j=1}^{m}\left(\frac{Count_{EE,j} \times Watts_{EE,j} \times Hours_j}{1000}\right)$$

$$\Delta kW = \sum_{i=1}^{n}\left(\frac{LPD_{BASE,i} \times Area_i}{1000}\right) - \sum_{j=1}^{m}\left(\frac{Count_{EE,j} \times Watts_{EE,j}}{1000}\right)$$

Where:

n	=	Total number of spaces in Space-by-Space Method or 1 for Building Area Method
m		Total number of efficient fixture types installed
$LPD_{BASE,i}$	=	Baseline lighting power density for building or space type i (Watts/ft^2)
$Area_i$	=	Area of building or space *i* (ft^2)
$Hours_i$	=	Annual hours of operation of the lighting equipment for building or space type *i*
$Count_{EE,j}$	=	Quantity of efficient fixture type j
$Watts_{EE,j}$	=	Wattage of fixture type j (Watts)
1000	=	Conversion factor: 1000 watts per 1 kW

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates.

Baseline Efficiency

The Baseline Efficiency assumes compliance with lighting power density requirements as mandated by Massachusetts State Building Code. As described in Chapter 13 of the aforementioned document, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2009. IECC 2009 offers one compliance path, the Building Area Method. IECC 2012 offers two compliance paths, the Building Area Method and Space-by-Space Method. ASHRAE 90.1-2007 offers two compliance paths. Current Massachusetts Building Code reflects IECC 2009, but revision is anticipated upon expected state adoption of IECC 2012. For completeness, the lighting power density requirements for both the Building Area Method and the Space-by-Space Method are presented.[362] Table 54 and Table 55 in Appendix A: Common Lookup Tables detail the specific power requirements by compliance path.

High Efficiency

The high efficiency scenario assumes lighting systems that achieve lighting power densities below those required by Massachusetts State Building Code. Actual site lighting power densities should be determined on a case-by-case basis. Please refer to the current year application form for minimum percentage better than code efficiency requirements.

Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis. If site-specific hours are unavailable, refer to the default hours in Table 59 in Appendix A: Common Lookup Tables.

Measure Life

The measure life for all new construction lighting installations is 15 years.[363]

Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat. This impact is estimated as an average impact in heating fossil fuel consumption per unit of energy saved.

Measure	Energy Type	Impact (MMBtu/ΔkWh)[364]
Interior Lighting	C&I Gas Heat	-0.0003649
Interior Lighting	Oil	-0.0007129

[362] IECC 2009 presents requirements consistent with ASHRAE 90.1-2007 for the Building Area Method but does not present requirements for the Space-by-Space Method. IECC 2012 recognizes the Space-by-Space Method with some changes to space types and power allowances.
[363] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[364] Optimal Energy, Inc. (2008). *MEMO: Non-Electric Benefits Analysis Update*. Prepared for NSTAR. Final savings values calculated in spreadsheet analysis as noted on pg 5 of the memo.

Non-Energy Impacts

Annual non-energy benefits are claimed due to the reduced operation and maintenance costs associated with the longer measure lived of lamps and ballasts as compared to the base or pre-retrofit case. See Appendix C: Non-Resource Impacts.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
All	NC	National Grid	1.00	1.00	1.07	0.80	0.73	custom	custom	n/a	n/a
All	NC	NSTAR	1.00	1.00	1.14	1.11	1.30	0.85	0.59	n/a	n/a
All	NC	CLC	1.00	1.00	1.14	1.11	1.30	0.85	0.59	n/a	n/a
All	NC	Unitil	1.00	1.00	1.00	1.00	1.00	0.85	0.59	n/a	n/a
All	NC	WMECO	1.00	1.00	1.05	1.11	1.30	0.85	0.59	0.89	0.58

Note: Realization Rates and Coincidence Factors have the HVAC Interactive Effect incorporated, see note in Algorithm section.

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid: energy and demand RRs derived from impact evaluation of National Grid 2008 custom lighting installations[365]; final realization rates developed in 2008 custom program analysis study[366]
- NSTAR, CLC: energy and demand RRs from impact evaluation of NSTAR 2007 lighting installations[367]
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- WMECO: energy RRs are from 2007/2008 Large C&I Programs impact evaluation[368], demand RRs from impact evaluation of NSTAR 2007 lighting installations referenced above.

Coincidence Factors
- National Grid, CFs are custom calculated based on site-specific information.
- NSTAR, WMECo, Unitil, CLC: CFs from the 2011 NEEP C&I Lighting Loadshape Study[369]

[365] KEMA, Inc. (2009). *National Grid USA 2008 Custom Lighting Impact Evaluation, Final Report*. Prepared for National Grid.
[366] KEMA, Inc. (2009). *Sample Design and Impact Evaluation Analysis of the the 2008 Custom Program.* Prepared for National Grid; Table 19.
[367] KEMA, Inc. (2009). *2007 Business & Construction Solutions (BS/CS) Programs - Measurement and Verification of 2007 Lighting Measures*. Prepared for NSTAR; Table Ex 3.
[368] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.
[369] KEMA (2011). C&I Lighting Loadshape Project – Final Report. Prepared for the Regional Evaluation, Measurement and Verification Forum.

Lighting – Lighting Systems

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure promotes the installation of efficient lighting including, but not limited to, efficient fluorescent lamps, ballasts, and fixtures, solid state lighting, and efficient high intensity discharge (HID) lamps, ballasts, and fixtures.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: O&M
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Lighting
Program: C&I New Construction & Major Renovation, C&I Large Retrofit, C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \left[\sum_{i=1}^{n} \left(\frac{Count_i * Watts_i}{1000} \right)_{BASE} - \sum_{j=1}^{m} \left(\frac{Count_j * Watts_j}{1000} \right)_{EE} \right] (Hours)$$

$$\Delta kW = \sum_{i=1}^{n} \left(\frac{Count_i * Watts_i}{1000} \right)_{BASE} - \sum_{j=1}^{m} \left(\frac{Count_j * Watts_j}{1000} \right)_{EE}$$

Where:

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

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates (See Impact Factors section).

Baseline Efficiency

For retrofit installations, the baseline efficiency case is project-specific and is determined using actual fixture counts from the existing space. Existing fixture wattages are provided in the MassSAVE Retrofit

Lighting Wattage Tables[370]. For lost opportunity installations, the baseline efficiency case is determined using assumed baseline wattages for each of the installed fixtures[371].

High Efficiency

For both new construction and retrofit installations, the high efficiency case is project-specific and is determined using actual fixture counts for the project and the MassSave Wattage Tables[372] in Appendix A: Common Lookup Tables.

Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis. If site-specific hours of operation are unavailable, refer to the default hours presented in Table 59 in Appendix A: Common Lookup Tables.

Measure Life

Lighting system measure lives vary by market sector and equipment type.

Measure Lives for C&I Lighting Systems[373]

Equipment Type	Measure Life (years)	
	Retrofit	Lost Opportunity
Bulb – CFL screw base	5	N/A
Fluorescent Fixture[374]	13	15
Hardwired CFL	13	15
LED Exit Signs	13	15
HID (interior and exterior)	13	15
LED Lighting Fixtures	13	15
LED Integral Replacement Lamps	13	15
LED Low Bay – Garage & Canopy Fixtures	13	15
Upstream Lighting – LED[375]	N/A	10
Upstream Lighting – T8/T5[376]	N/A	10

Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat. This impact is estimated as an average impact in heating fossil fuel consumption per unit of energy saved.

[370] MassSave (2010). *C&I Retrofit Lighting Wattage Tables.*
[371] Massachusetts Common Assumption: Baseline wattage per fixture type based on comparable code-compliant installations and standard practice.
[372] MassSave (2010). *C&I New Construction Lighting Wattage Tables* AND MassSave (2010). *C&I Retrofit Lighting Wattage Tables.*
[373] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1 AND GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measure*s. Prepared for The New England State Program Working Group; Table 2
[374] The lifetime for measures replacing T12s has been reduced for the years 2013-2015 to 5.52, 4.98, and 4.57 which accounts for the effects of EISA (Energy Independence and Security Act of 2007).
[375] Estimate based on average life of eligible products at retail operating hours.
[376] MA Common Assumption.

Program	Measure	Energy Type	Impact (MMBtu/ΔkWh)[377]
Large CI	Interior Lighting	C&I Gas Heat	-0.0003649
Large CI	Interior Lighting	Oil	-0.0007129
Small Retrofit	Interior Lighting	Gas Heat	-0.001075
Small Retrofit	Interior Lighting	Oil Heat	-0.000120

Non-Energy Impacts

Annual non-energy benefits are claimed due to the reduced operation and maintenance costs associated with the longer measure lived of lamps and ballasts as compared to the base or pre-retrofit case. See Appendix C: Non-Resource Impacts.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Large C&I New Construction and Large C&I Retrofit											
All	NC	CLC	1.00	1.00	1.14	1.11	1.30	0.85	0.59	n/a	n/a
All	Retrofit	CLC	1.00	1.00	1.01	1.18	1.26	0.85	0.59	n/a	n/a
All	NC	National Grid	1.00	1.00	0.99	0.97	0.97	0.98	0.73	n/a	n/a
All	Retrofit	National Grid	1.00	1.00	1.04	1.03	1.03	0.89	0.63	n/a	n/a
All	NC	NSTAR	1.00	1.00	1.14	1.11	1.30	0.85	0.59	n/a	n/a
All	Retrofit	NSTAR	1.00	1.00	1.01	1.18	1.26	0.85	0.59	n/a	n/a
All	NC	Unitil	1.00	1.00	1.00	1.00	1.00	0.85	0.59	n/a	n/a
All	Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.85	0.59	n/a	n/a
All	NC	WMECO	1.00	1.00	1.05	1.11	1.30	0.85	0.59	0.89	0.58
All	Retrofit	WMECO	1.00	1.00	1.05	1.18	1.26	0.85	0.59	0.89	0.58
Small C&I Retrofit											
All	Retrofit	CLC	1.00	1.00	1.02	0.99	0.99	0.72	0.44	n/a	n/a
All	Retrofit	National Grid	1.00	1.00	1.02	0.99	0.99	0.73	0.44	n/a	n/a
CFLs, Interior	Retrofit	National Grid	1.00	0.87	1.02	0.99	0.99	0.73	0.44	n/a	n/a
All	Retrofit	NSTAR	1.00	1.00	1.02	0.99	0.99	0.73	0.44	n/a	n/a
All	Retrofit	Unitil	1.00	1.00	1.02	0.99	0.99	0.72	0.44	n/a	n/a
All	Retrofit	WMECO	1.00	1.00	1.02	0.99	0.99	0.73	0.44	0.67	0.42

Note: Realization Rates and Coincidence Factors have the HVAC Interactive Effect incorporated, see note in Algorithm section.

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

Savings Persistence Factor
All PAs use 100% savings persistence factors with one exception: National Grid uses 0.87 for screw-in CFLs installed through the C&I Small Retrofit program based on 1996 savings persistence study[378].

[377] Optimal Energy, Inc. (2008). *MEMO: Non-Electric Benefits Analysis Update*. Prepared for NSTAR. Final savings values calculated in spreadsheet analysis as noted on pg 5 of the memo **AND** Small Retrofit; *Non-Controls Lighting Evaluation for the Massachusetts Small Business Direct Install Program: Multi-Season Study*, The Cadmus Group, June 12, 2012 .

Realization Rates

New Construction & Major Renovation Commercial

- National Grid energy and demand RRs from impact evaluation of National Grid's 2007 Design 2000plus (New Construction) Lighting installations[379]. Demand RR is the connected demand RR; energy RR includes connected demand RR, hours of use RR and HVAC Interactive adjustment.
- NSTAR, CLC energy and demand RRs from impact evaluation of NSTAR's Business & Construction Solutions Programs Lighting installations[380]. Energy and demand realization rates include interactive adjustments.
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- WMECO: energy RRs are from 2007/2008 Large C&I Programs impact evaluation[381], demand RRs from NSTAR's Business & Construction Solutions Programs Lighting Installations referenced above.

C&I Large Retrofit

- National Grid energy RR is from impact evaluation of National Grid's 2007 Energy Initiative (Large Retrofit) Lighting program[382]. Energy RR is the ratio measured electric energy savings to gross estimates of electric energy savings, and includes electric HVAC interaction adjustment by default. National Grid demand RRs are from impact evaluation of National Grid's 2003 Energy Initiative Lighting program[383]. Demand RR is the connected demand RR.
- NSTAR, CLC, Unitil, WMECO: Same as *New Construction & Major Renovation Commercial*

C&I Small Retrofit

- Energy and demand RRs are the statewide results from the 2011 Small C&I Non-Controlled Lighting impact evaluation[384]

Coincidence Factors

New Construction & Major Renovation Commercial

All CFs are from the 2011 NEEP C&I Lighting Loadshape Project[385] except:
National Grid CFs from National Grid's 2007 Design 2000*plus* Lighting subprogram[386]

C&I Large Retrofit

All CFs are from the 2011 NEEP C&I Lighting Loadshape Project[387]

C&I Small Retrofit

All PAs use CF values from the 2012 the Cadmus Non-Controls Multi-Season Lighting Evaluation.[388]

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[378] HEC, Inc. (1996). *Persistence of Savings Study*. Prepared for New England Power Service Company.
[379] KEMA, Inc. (2009). *Design 2000plus Lighting Hours of Use and Load Shapes Measurement Study*. Prepared for National Grid.
[380] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas
[381] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.
[382] Summit Blue Consulting, LLC (2008). *Large Commercial and Industrial Retrofit Program Impact Evaluation 2007 – Final Report*. Prepared for National Grid.
[383] RLW Analytics (2004). *2003 Energy Initiative "EI" Program Lighting Impact Evaluation - Final Report*. Prepared for National Grid.
[384] The Cadmus Group. (2012). *Non-Controls Lighting Evaluation for the Massachusetts Small Business Direct Install Program: Multi-Season Study*. Prepared for Massachusetts Joint Utilities.
[385] KEMA (2011). C&I Lighting Loadshape Project – Final Report. Prepared for the Regional Evaluation, Measurement and Verification Forum.
[386] KEMA, Inc. (2009). *Design 2000plus Lighting Hours of Use and Load Shapes Measurement Study*. Prepared for National Grid.
[387] KEMA (2011). C&I Lighting Loadshape Project – Final Report. Prepared for the Regional Evaluation, Measurement and Verification Forum.

Lighting – Lighting Controls

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure promotes the installation of lighting controls in both lost-opportunity and retrofit applications. Promoted technologies include occupancy sensors and daylight dimming controls.
Primary Energy Impact: Electric
Secondary Energy Impact: Heating energy (non-electric)
Non-Energy Impacts: O&M
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Lighting
Program: C&I New Construction & Major Renovation, C&I Large Retrofit, C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kW = (Controlled\,kW)(Hours_{BASE} - Hours_{EE})$$
$$\Delta kW = (Controlled\,kW)$$

Where:

Controlled kW	=	Controlled fixture wattage
$Hours_{BASE}$	=	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).
$Hours_{EE}$	=	Total annual hours that the connect Watts operate with the lighting controls implemented.

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates (See Impact Factors section).

Baseline Efficiency

The baseline efficiency case assumes no controls (retrofit) or code-compliant controls (new construction).

[388] The Cadmus Group. (2012). *Non-Controls Lighting Evaluation for the Massachusetts Small Business Direct Install Program: Multi-Season Study*. Prepared for Massachusetts Joint Utilities.

High Efficiency

The high efficiency case involves lighting fixtures connected to controls that reduce the pre-retrofit or baseline hours of operation.

Hours

The annual hours of reduction for lighting controls are site-specific and should be determined on a case-by-case basis. If site-specific hours are unavailable, refer to the default hours in Table 59 in Appendix A: Common Lookup Tables.

Measure Life

Lighting system measure lives vary by market sector and equipment type.

Measure Lives for C&I Lighting Controls[389]

Measure	Measure Life (years)	
	Retrofit	Lost Opportunity
Occupancy Sensors	9	10
Daylight Dimming	9	10

Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat. This impact is estimated as an average impact in heating fossil fuel consumption per unit of energy saved.

	Measure	Energy Type	Impact (MMBtu/ΔkWh)[390]
Large CI	Interior Lighting	C&I Gas Heat	-0.0003649 MMBtu/kWh
Large CI	Interior Lighting	Oil	-0.0007129 MMBtu/kWh
Small Retrofit	Interior Lighting	Gas Heat	-0.000743 MMBtu/kWh
Small Retrofit	Interior Lighting	Oil	-0.000132 MMBtu/kWh

Non-Energy Impacts

Annual non-energy benefits are claimed due to the reduced operation and maintenance costs associated with the longer measure lived of lamps and ballasts as compared to the base or pre-retrofit case. See Appendix C: Non-Resource Impacts.

[389] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[390] Optimal Energy, Inc. (2008). *MEMO: Non-Electric Benefits Analysis Update*. Prepared for NSTAR. Final savings values calculated in spreadsheet analysis as noted on pg 5 of the memo AND for Small Retrofit, The Cadmus Group, Inc. (2012), *Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study*.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Large C&I New Construction and Large C&I Retrofit											
Occupancy Sensors	All	National Grid	1.00	1.00	0.76	0.96	0.96	0.30	0.19	n/a	n/a
Daylight Dimming	All	National Grid	1.00	1.00	0.38	0.96	0.96	0.15	0	n/a	n/a
All	NC	NSTAR, CLC	1.00	1.00	1.14	1.11	1.30	0.85	0.59	n/a	n/a
All	Retrofit	NSTAR, CLC	1.00	1.00	1.01	1.18	1.26	0.85	0.59	n/a	n/a
All	All	Unitil	1.00	1.00	1.00	1.00	1.00	0.85	0.59	n/a	n/a
All	NC	WMECO	1.00	1.00	1.05	1.11	1.30	0.85	0.59	n/a	n/a
All	Retrofit	WMECO	1.00	1.00	1.05	1.18	1.26	0.85	0.59	custom	custom
Small C&I Retrofit											
Occupancy Sensors	All	National Grid	1.00	1.00	0.42	0.92	0.92	0.18	0.12	n/a	n/a
All	All	NSTAR, CLC	1.00	1.00	0.42	0.92	0.92	0.18	0.12	n/a	n/a
All	All	Unitil	1.00	1.00	0.42	0.92	0.92	0.18	0.12	n/a	n/a
All	All	WMECO	1.00	1.00	0.42	0.92	0.92	0.18	0.12	custom	custom

Note: Realization Rates and Coincidence Factors have the HVAC Interactive Effect incorporated, see note in Algorithm section.

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
All PAs use the same RRs as for Lighting Systems installations, except National Grid Small C&I Retrofit:
- National Grid Large C&I RRs from National Grid impact evaluation of C&I lighting controls installations.[391]
- All PA, Small C&I Retrofit RRs from statewide Pre/Post Occupancy Sensor study.[392]

Coincidence Factors
All PAs use the same CFs as for Lighting Systems installations, except National Grid:
- National Grid Large CI CFs from National Grid impact evaluation C&I lighting controls installations.[393]
- All PA Small C&I Retrofit CFs from statewide Pre/Post Occupancy Sensor study.[394]

[391] RLW Analytics (2007). *Lighting Controls Impact Evaluation - Final Report, 2005 Energy Initiative, Design 2000plus and Small Business Services Programs*. Prepared for National Grid.
[392] The Cadmus Group, Inc. (2012). *Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study.*
[393] RLW Analytics (2007). *Lighting Controls Impact Evaluation - Final Report, 2005 Energy Initiative, Design 2000plus and Small Business Services Programs*. Prepared for National Grid.
[394] The Cadmus Group, Inc. (2012). *Final Report, Small Business Direct Install Program: Pre/Post Occupancy Sensor Study.*

Lighting – Freezer/Cooler LEDs

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of LED lighting in freezer and/or cooler cases. The LED lighting consumes less energy, and results in less waste heat which reduces the cooling/freezing load.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Lighting
Program: C&I Large Retrofit, C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh_{LED} = \sum_{i=1}^{n} \left(Count_i * kW_i * Hours_i \right)_{BASE} - \sum_{i=1}^{m} \left(Count_j * kW_j * Hours_j \right)_{LED}$$

$$\Delta kWh_{Heat} = \Delta kWh_{LED} * 0.28 * Eff_{RS}$$

$$\Delta kW = \Delta kWh / Hours_j$$

Where:

ΔkWh_{LED}	=	Reduction in lighting energy
ΔkWh_{Heat}	=	Reduction in refrigeration energy due to reduced heat loss from the lighting fixtures
N	=	Total number of lighting fixture types in the pre-retrofit case
M	=	Total number of lighting fixture types in the post-retrofit case
$Count_i$	=	Quantity of type i fixtures in the pre-retrofit case
kW_i	=	Power demand of pre-retrofit lighting fixture type i (kW/fixture)
$Hours_i$	=	Pre-retrofit annual operating hours of fixture type i
$Count_j$	=	Quantity of type j fixtures in the pre-retrofit case
kW_j	=	Power demand of lighting fixture type j (kW/fixture)
$Hours_j$	=	Post-retrofit annual operating hours of fixture type j
0.28	=	Unit conversion between kW and tons calculated as 3,413 Btuh/kW divided by 12,000 Btuh/ton
Eff_{RS}	=	Efficiency of typical refrigeration system: 1.6 kW/ton[395]

[395] Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

Baseline Efficiency

The baseline efficiency case is the existing lighting fixtures in the cooler or freezer cases.

High Efficiency

The high efficiency case is the installation of LED lighting fixtures on the cooler or freezer cases, replacing the existing lighting fixtures.

Hours

Annual hours of operation are determined on a case-by-case basis and are typically 8760 hours/year. Post-retrofit operating hours are assumed to be the same as pre-retrofit hours unless lighting occupancy sensors were also implemented.

Measure Life

The measure life is 13 years.[396]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Freezer/Cooler LEDs	Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Large Retrofit	NSTAR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Large Retrofit	CLC, Unitil	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Large Retrofit	WMECO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Freezer/Cooler LEDs	Small Retrofit	National Grid	1.00	1.00	1.04	1.07	1.15	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	NSTAR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	CLC, Unitil	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Freezer/Cooler LEDs	Small Retrofit	WMECO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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

[396] Energy & Resource Solutions (2005*). Measure Life Study*. Prepared for The Massachusetts Joint Utilities.

Savings Persistence Factor

All PAs use 100% savings persistence factor.

Realization Rates

- National Grid: RRs for small retrofit installations based on impact evaluation of 2005 small retrofit custom measures[397]; RRs for large retrofit installations are 100% based on no evaluations
- NSTAR, WMECo, CLC, Unitil: energy and demand RRs are 100% based on no evaluations

Coincidence Factors

- National Grid, Unitil, NSTAR, WMECo: CFs set to 100% because pre-retrofit unit operate 8760 hours/year.

[397] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation*. Prepared for National Grid.

HVAC – Single–Package and Split System Unitary Air Conditioners

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure promotes the installation of high efficiency unitary air conditioning equipment in lost opportunity applications. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure applies to air, water, and evaporatively-cooled unitary AC systems, both single-package and split systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

For units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{Cool})$$

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

Through 2013 - For units with cooling capacities equal to or greater than 65 kBtu/h:

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

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

Starting 2014 - For units with cooling capacities equal to or greater than 65 kBtu/h:

$$\Delta kWh = (kBtu/h)\left(\frac{1}{IEER_{BASE}} - \frac{1}{IEER_{EE}}\right)(Hours_{Cool})$$

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

Where:

ΔkWh	=	Gross annual kWh savings from the measure.
ΔkW	=	Gross connected kW savings from the measure.
kBtu/h	=	Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h)
$SEER_{BASE}$	=	Seasonal Energy Efficiency Ratio of the baseline equipment. See Table 18 for values.
$SEER_{EE}$	=	Seasonal Energy Efficiency Ratio of the energy efficient equipment.
$EFLH_{Cool}$	=	Cooling equivalent full load hours. See Appendix A: Common Lookup Tables Table 60 for default values.
EER_{BASE}	=	Energy Efficiency Ratio of the baseline equipment. See Table 18 for values. Since IECC 2009 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
EER_{EE}	=	Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EER_{EE} is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.
$IEER_{BASE}$	=	Integrated Energy Efficiency Ratio of the baseline equipment. See Table 18 for values.
$IEER_{EE}$	=	Integrated Energy Efficiency Ratio of the energy efficient equipment.
$Hours_{Cool}$	=	Annual Cooling Hours[398]

Baseline Efficiency

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. Until 1/1/2014, as described in Chapter 13 of the aforementioned document, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2009 with Massachusetts specific amendments.[399] After 1/1/2014, energy efficiency must be met via compliance with IECC 2012 with Massachusetts specific amendments.[400]

Table 18: Unitary Air Conditioners Baseline Efficiency Levels

Equipment Type	Size Category	Subcategory or Rating Condition	Baseline Efficiency Until 1/2014	Baseline Efficiency After 1/2014
Air conditioners, air cooled	<65,000 Btu/h[b]	Split system	13.0 SEER	13.0 SEER
		Single package	13.0 SEER	13.0 SEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.2 EER[a] 11.4 IEER[a]	11.2 EER[a] 11.4 IEER[a]
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER[a] 11.2 IEER[a]	11.0 EER[a] 11.2 IEER[a]
	≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	10.0 EER[a] 10.1 IEER[a]	10.0 EER[a] 10.1 IEER[a]
	≥760,000 Btu/h	Split system and single package	9.7 EER[a] 9.8 IEER[a]	9.7 EER[a] 9.8 IEER[a]

[398] Annual Cooling Hours for Unitary HVAC equipment under development
[399] International Code Council (2009). *2009 International Energy Conservation Code*; Page43, Table 503.2.3(1).
[400] International Code Council (2012). *2012 International Energy Conservation Code*; Page C-38, Table C403.2.3(1).

Equipment Type	Size Category	Subcategory or Rating Condition	Baseline Efficiency Until 1/2014	Baseline Efficiency After 1/2014
Air conditioners, Water cooled	<65,000 Btu/h	Split system and single package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.5 EER[a] 11.7 IEER[a]	12.1 EER[a] 12.3 IEER[a]
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER[a] 11.2 IEER[a]	12.5 EER[a] 12.7 IEER[a]
	≥240,000 Btu/h	Split system and single package	11.0 EER[a] 11.1 IEER[a]	12.4 EER[a] 12.6 IEER[a]
Air conditioners, evaporatively cooled	<65,000 Btu/h	Split system and single package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.5 EER[a] 11.7 IEER[a]	12.1 EER[a] 12.3 IEER[a]
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER[a] 11.2 IEER[a]	12.0 EER[a] 12.2 IEER[a]
	≥240,000 Btu/h	Split system and single package	11.0 EER[a] 11.1 IEER[a]	11.9 EER[a] 12.1 IEER[a]

a. Deduct 0.2 from the required EERs for units with a heating section other than electric heat.[401]
b. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

High Efficiency

The high efficiency case assumes the HVAC equipments 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. The minimum efficiency requirements for program participation are outlined on the Cool Choice rebate forms. Equipment efficiency is the rated efficiency of the installed equipment for each project.

Hours

If site-specific hours are unavailable, the equivalent cooling full load hours for unitary AC equipment are determined from the facility type. See Appendix A: Common Lookup Tables for cooling full load hours by building type.

Measure Life

The measure life is 15 years.[402]

[401] The PAs do not differentiate between units by heating section types. To be conservative, the highest Baseline Efficiency is assumed for all heating section types in each equipment category.
[402] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Unitary AC	NC	CLC	1.00	1.00	1.00	0.74	0.00	0.45	0.00	n/a	n/a
Unitary AC	NC	National Grid	1.00	1.00	1.00	1.00	1.00	0.40	0.00	n/a	n/a
Unitary AC	NC	NSTAR	1.00	1.00	1.00	0.74	0.00	0.45	0.00	n/a	n/a
Unitary AC	NC	Unitil	1.00	1.00	1.00	1.00	1.00	0.33	0.00	n/a	n/a
Unitary AC	NC	WMECO	1.00	1.00	0.91	0.74	0.00	0.45	0.00	0.42	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
- CLC, National Grid, NSTAR, Unitil: Energy RRs set to 1.00 based 2011 NEEP C&I Unitary AC Loadshape Project.[403]
- WMECO: Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[404]

Coincidence Factors
CFs based 2011 NEEP C&I Unitary AC Loadshape Project.[405]

[403] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.
[404] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.
[405] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

HVAC – Single Package or Split System Heat Pump Systems

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

For air cooled units with cooling capacities less than 65 kBtu/h:

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

$$\Delta kWh_{Cool} = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{COOL})$$

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

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

For all water source, groundwater source, and ground source units. Through 2013- for air cooled units. with cooling capacities equal to or greater than 65 kBtu/h:

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

$$\Delta kWh_{Cool} = (kBtu/h_{COOL})\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{COOL})$$

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

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

Starting 2014- for air cooled units. with cooling capacities equal to or greater than 65 kBtu/h:

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

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

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

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

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[406]	=	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 Table 19 for values.
$SEER_{EE}$	=	Seasonal Energy Efficiency Ratio of the energy efficient equipment.
$EFLH_{COOL}$	=	Cooling mode equivalent full load hours.
$HSPF_{BASE}$	=	Heating Seasonal Performance Factor of the baseline equipment. See Table 19 for values.
$HSPF_{EE}$	=	Heating Seasonal Performance Factor of the energy efficient equipment.
$EFLH_{HEAT}$	=	Heating mode equivalent full load hours.
$kBtu/h_{COOL}$	=	Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
EER_{BASE}	=	Energy Efficiency Ratio of the baseline equipment. See Table 19 for values. Since IECC 2009 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.
EER_{EE}	=	Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EER_{EE} is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.
$kBtu/h_{HEAT}$	=	Capacity of the heating equipment in kBtu per hour. If the heating capacity is unknown, it can be calculated from the cooling capacity using the conversion factors defined below.
3.412	=	Conversion factor: 3.412 Btu per Wh.
COP_{BASE}	=	Coefficient of performance of the baseline equipment. See Table 19 for values.
COP_{EE}	=	Coefficient of performance of the energy efficient equipment.
$IEER_{BASE}$	=	Integrated Energy Efficiency Ratio of the baseline equipment. See Table 18 for values.
$IEER_{EE}$	=	Integrated Energy Efficiency Ratio of the energy efficient equipment.
$Hours_{Cool}$	=	Annual Cooling Hours[407]

Heating Capacity Conversion Factors:

Air Source HPs

[406] For equipment with cooling capacities less than 65 kBtu/h, it is assumed that the heating capacity and cooling capacity are equal.
[407] Annual Cooling Hours for Unitary HVAC equipment under development

Heating Capacity = Cooling Capacity * 13,900/12,000 (Ratio of heat produced in the heating mode divided by cooling produced in cooling mode)

Water/Ground Source HPs
Heating Capacity = Cooling Capacity * COP/EER (converts the rated cooling output to the rated heating output)

Baseline Efficiency

The baseline efficiency case for new installations 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) 2009 with Massachusetts specific amendments until 1/1/2014.[408] After 1/1/2014, baseline efficiency requirements will follow IECC 2012 with Massachusetts specific amendments.[409] Table 19 details the specific efficiency requirements by equipment type and capacity.

Table 19: Unitary and Applied Heat Pumps Baseline Efficiency Levels

Equipment Type	Size Category (Cooling Capacity)	Subcategory or Rating Condition	Baseline Efficiency Until 1/1/2014		Baseline Efficiency After 1/1/2014	
			Cooling Mode	Heating Mode	Cooling Mode	Heating Mode
Air cooled	<65,000 Btu/h[b]	Split system	13.0 SEER	7.7 HSPF	13.0 SEER	7.7 HSPF
		Single package	13.0 SEER	7.7 HSPF	13.0 SEER	7.7 HSPF
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	11.0 EER[a]	3.3 COP	11.0 EER[a] 11.2 IEER[a]	3.3 COP
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	10.6 EER[a]	3.2 COP	10.6 EER[a] 10.7 IEER[a]	3.2 COP
	≥240,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	9.5 EER[a]	3.2 COP	9.5 EER[a] 9.6 IEER[a]	3.2 COP
Water source	<17,000 Btu/h	86°F entering water (Cooling Mode) / 68°F entering water (Heating Mode)	11.2 EER	4.2 COP	11.2 EER	4.2 COP
	≥17,000 Btu/h and <135,000 Btu/h	86°F entering water / 68°F entering water (Heating Mode)	12.0 EER	4.2 COP	12.0 EER	4.2 COP
Groundwater source	<135,000 Btu/h	59°F entering water (Cooling Mode) / 50°F entering water (Heating Mode)	16.2 EER	3.6 COP	16.2 EER	3.6 COP
Ground source	<135,000 Btu/h	77°F entering water / 32°F entering water (Heating Mode)	13.4 EER	3.1 COP	13.4 EER	3.1 COP

db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.

[408] International Code Council (2009). *2009 International Energy Conservation Code*; Page 44, Table 503.2.3(2).
[409] International Code Council (2012). *2012 International Energy Conservation Code*; Page C-40, Table C403.2.3(2).

a. Deduct 0.2 from the required EERs for units with a heating section other than electric heat[410].
b. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

High Efficiency

The high efficiency case assumes the HVAC equipments 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.

The minimum efficiency requirements for program participation are outlined on the Cool Choice rebate forms. Equipment efficiency is the rated efficiency of the installed equipment for each project.

Hours

The annual equivalent full load hours for single package or split system heat pump systems are site-specific and should be determined on a case-by-case basis. If site-specific hours are unavailable, refer to the default hours presented in Appendix A: Common Lookup Tables.

Measure Life

The measure life is 15 years.[411]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Heat Pumps	NC	National Grid	1.00	1.00	1.05	1.00	1.00	0.40	0.00	n/a	n/a
Heat Pumps	NC	NSTAR	1.00	1.00	1.01	1.09	1.57	0.45	0.00	n/a	n/a
Heat Pumps	NC	CLC	1.00	1.00	1.00	1.09	1.57	0.55	0.00	n/a	n/a
Heat Pumps	NC	Unitil	1.00	1.00	1.00	1.00	1.00	0.33	0.00	n/a	n/a
Heat Pumps	NC	WMECO	1.00	1.00	0.91	1.09	1.57	0.45	0.00	0.42	0.00

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

Savings Persistence Factor

[410] The PAs do not differentiate between units by heating section types. To be conservative, the highest baseline efficiency is assumed for all heating section types in each equipment category.
[411] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

All PAs use 100% savings persistence factors.

Realization Rates

- National Grid and energy and demand RRs based on a 1994 study of HVAC and process cooling equipment.[412]
- NSTAR energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[413]
- CLC realization rates same as Unitary AC.
- Unitil realization rates same as *Unitary AC*.
- WMECO: Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[414], demand realization rates from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors

- CFs based 2011 NEEP C&I Unitary AC Loadshape Project.[415]

[412] The Fleming Group (1994). *Persistence of Commercial/Industrial Non-Lighting Measures, Volume 2, Energy Efficient HVAC and Process Cooling Equipment*. Prepared for New England Power Service Company.
[413] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[414] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*
[415] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

HVAC – Dual Enthalpy Economizer Controls (DEEC)

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: The measure is to upgrade the outside-air dry-bulb economizer to a dual enthalpy economizer. The system will continuously monitor the enthalpy of both the outside air and return air. The system will control the system dampers adjust the outside quantity based on the two readings.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: HVAC
Program: C&I New Construction and Major Renovation

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (kBtu/h)\left(\frac{1\,Ton}{12\,kBtu/h}\right)(SAVE_{kWh})$$

$$\Delta kW = (kBtu/h)\left(\frac{1\,Ton}{12\,kBtu/h}\right)(SAVE_{kW})$$

Where:
kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
$SAVE_{kWh}$ = Average annual kWh reduction per ton of cooling capacity: 289 kWh/ton[416]
$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.289 kW/ton[417]

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.

[416] Patel, Dinesh (2001). *Energy Analysis: Dual Enthalpy Control*. Prepared for NSTAR.
[417] Ibid.

Hours

Not applicable.

Measure Life

The measure life is 10 years for lost-opportunity applications.[418] The measure life is 7 years for retrofit installations.[419]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
DEEC	NC	National Grid	1.00	1.00	1.00	1.00	1.00	0.40	0.00	n/a	n/a
DEEC	NC	NSTAR	1.00	1.00	1.01	1.09	1.57	0.45	0.00	n/a	n/a
DEEC	NC	CLC	1.00	1.00	1.00	1.09	1.57	0.55	0.00	n/a	n/a
DEEC	NC	Unitil	1.00	1.00	1.00	1.00	1.00	0.332	0.00	n/a	n/a
DEEC	NC	WMECO	1.00	1.00	0.91	1.09	1.57	0.45	0.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.
.

Realization Rates
- National Grid RRs are 1.0 since there have been no impact evaluations of the prescriptive savings calculations.
- NSTAR energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[420]
- CLC realization rates same as Unitary AC.
- Unitil realization rates same as *Unitary AC*.
- WMECO: Energy RRs are from 2007/2008 Large C&I Programs impact evaluation.[421], demand realization rates from impact evaluation NSTAR 2006 HVAC installations.

Coincidence Factors
- All PAs on-peak CFs based 2011 NEEP C&I Unitary AC Loadshape Project[422].

[418] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1
[419] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group; Table 2.
[420] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[421] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*
[422] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.

- WMECO: seasonal peak values set to 0.00 based on assumption that no DEEC savings occur during seasonal peak periods.

HVAC – ECM Fan Motors

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure is offered through the Cool Choice program and promotes the installation of electronically commutated motors (ECMs) on fan powered terminal boxes, fan coils, and HVAC supply fans on small unitary equipment.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Electric Energy Impact

$$\Delta kWh = (Design\,CFM)(Box\,Size\,Factor)(\%Flow_{ANNUAL})(Hours)$$
$$\Delta kW_{SP} = (Design\,CFM)(Box\,Size\,Factor)(\%Flow_{SP})$$
$$\Delta kW_{WP} = (Design\,CFM)(Box\,Size\,Factor)(\%Flow_{WP})$$

Where:
Design CFM = Capacity of the VAV box in cubic feet per minute
Box Size Factor = Savings factor in Watts/CFM. See Table 20 for values.
$\%Flow_{ANNUAL}$ = Average % of design flow over all operating hours. See Table 20 for values.
$\%Flow_{SP}$ = Average % of design flow during summer peak period. See Table 20 for values.
$\%Flow_{WP}$ = Average % of design flow during summer peak period. See Table 20 for values.
Hours = Annual operating hours for VAV box fans

Table 20: ECM Fan Motor Savings Factors [423]

Factor	Box Size	Value	Units
Box Size Factor	< 1000 CFM	0.32	Watts/CFM
Box Size Factor	≥ 1000 CFM	0.21	Watts/CFM
$\%Flow_{ANNUAL}$	All	0.52	-
$\%Flow_{SP}$	All	0.63	-
$\%Flow_{WP}$	All	0.33	-

Baseline Efficiency

The baseline efficiency case for this measure assumes the VAV box fans are powered by a single speed fractional horsepower permanent split capacitor (PSC) induction motor.

[423] Factors based on engineering analysis developed at National Grid.

High Efficiency

The high efficiency case must have a motor installed on new, qualifying HVAC equipment.

Hours

The annual operating hours for ECMs on VAV box fans are site-specific and should be determined on a case-by-case basis.

Measure Life

The measure life is 20 years for lost-opportunity applications.[424]

Algorithms for Calculating Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
ECM Fan Motors	NC	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
ECM Fan Motors	NC	NSTAR, CLC	1.00	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
ECM Fan Motors	NC	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	0.82	n/a	n/a
ECM Fan Motors	NC	WMECO	1.00	1.00	1.31	1.09	1.57	0.82	0.05	0.72	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
- National Grid: RRs based on engineering estimates
- NSTAR, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[425]
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- WMECO: Energy RRs are from 2007/2008 Large C&I Programs impact evaluation[426], demand realization rates from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors
- National Grid: CFs based on engineering estimates.
- NSTAR, CLC, Unitil, WMECO: on-peak CFs based on standard assumptions.
- WMECO: seasonal peak values from 2005 coincidence factor study[427]

[424] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[425] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[426] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

HVAC – Energy Management System

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: The measure is the installation of a new building energy management system (EMS) or the expansion of an existing energy management system for control of non-lighting electric and gas end-uses in an existing building on existing equipment.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas, Oil
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Program: C&I New Construction & Major Renovation, C&I Large Retrofit, C&I Small Retrofit

Algorithms for Calculating Primary Energy Impacts

Gross energy and demand savings for energy management systems (EMS) are custom calculated using the PA's EMS savings calculation tools. These tools are used to calculate energy and demand savings based on project-specific details including hours of operation, HVAC system equipment and efficiency and points controlled.[428]

Baseline Efficiency

The baseline for this measure assumes the relevant HVAC equipment has no control.

High Efficiency

The high efficiency case is the installation of a new EMS or the expansion of an existing EMS to control additional non-lighting electric or gas equipment. The EMS must be installed in an existing building on existing equipment.

Hours

Not applicable.

[427] RLW Analytics (2007). *Final Report, 2005 Coincidence Factor Study.* Prepared for Connecticut Energy Conservation Management Board, United Illuminating and Connecticut Light & Power.
[428] Descriptions of the EMS savings calculation tools are included in the TRM Library "C&I Spreadsheet Tools" folder.

Measure Life

For lost-opportunity applications, the measure life is 15 years[429]. For retrofit applications, the measure life is 10 years[430].

Secondary Energy Impacts

Heating Impacts: Gas and oil heat impacts are counted for EMS measures for reduction in space heating. If the heating system impacts are not calculated in the EMS savings calculation tool, they can be approximated using the interaction factors described below:

Measure	Energy Type	Impact (MMBtu/ΔkWh)[431]
EMS	C&I Gas Heat	0.001277
EMS	Oil	0.002496

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
EMS	Large Retrofit	National Grid	1.00	1.00	1.04	1.03	1.03	custom	custom	n/a	n/a
EMS	Large Retrofit	NSTAR, CLC	1.00	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
EMS	Large Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.82	0.05	n/a	n/a
EMS	Large Retrofit	WMECO	1.00	1.00	0.57	1.09	1.57	0.82	0.05	custom	custom
EMS	Small Retrofit	CLC	1.00	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
- National Grid RRs derived from a 1994 study of hvac and process cooling equipment.[432]
- NSTAR, CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[433]
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations
- WMECO: Energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[434], demand RRs from impact evaluation of NSTAR 2006 HVAC installations referenced above.

[429] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[430] Ibid.
[431] Optimal Energy, Inc. (2008). *MEMO: Non-Electric Benefits Analysis Update*. Prepared for NSTAR. Final savings values calculated in spreadsheet analysis as noted on pg 5 of the memo.
[432] The Fleming Group (1994). *Persistence of Commercial/Industrial Non-Lighting Measures, Volume 3, Energy Management Control Systems*. Prepared for New England Power Service Company.
[433] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[434] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

Coincidence Factors

- National Grid: CFs are custom calculated.
- NSTAR, CLC, Unitil, WMECO: on-peak CFs based on standard assumptions.
- WMECO: seasonal CFs are custom calculated.

HVAC – High Efficiency Chiller

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure promotes the installation of efficient water-cooled and air-cooled water chilling packages for comfort cooling applications. Eligible chillers include air-cooled, water cooled rotary screw and scroll, and water cooled centrifugal chillers for single chiller systems or for the lead chiller only in multi-chiller systems.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Gross energy and demand savings for chiller installations may be custom calculated using the PA's Chillers savings calculation tool. These tools are used to calculated energy and demand savings based on site-specific chiller plant details including specific chiller plan equipment, operational staging, operating load profile and load profile.[435]

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:

Air-Cooled Chillers:

$$\Delta kWh = (Tons)\left(\frac{12}{EER_{BASE}} - \frac{12}{EER_{EE}}\right)(Hours)$$

$$\Delta kW = (Tons)\left(\frac{12}{EER_{BASE}} - \frac{12}{EER_{EE}}\right)(LF)$$

Water-Cooled Chillers:

$$\Delta kWh = (Tons)(kW/ton_{BASE} - kW/ton_{EE})(Hours)$$

[435] Descriptions of the Chiller savings calculation tools are included in the TRM Library "C&I Spreadsheet Tools" folder.

$$\Delta kW = (Tons)\left(kW / ton_{BASE} - kW / ton_{EE}\right)\left(LF\right)$$

Where:

Tons = Rated capacity of the cooling equipment
EER_{BASE} = Energy Efficiency Ratio of the baseline equipment. See Table 21 for values.
EER_{EE} = Energy Efficiency Ratio of the efficient equipment. Site-specific.
kW/ton_{BASE} = Energy efficiency rating of the baseline equipment. See Table 21 for values.
kW/ton_{EE} = Energy efficiency rating of the efficient equipment. Site-specific.
Hours = Equivalent full load hours for chiller operation
LF = Load Factor. See table below

Equipment Type	PA	Load Factor[436,437]	
		Full Load	IPLV
Air-cooled chillers	National Grid	0.715	
Water cooled chillers < 300 Tons	National Grid	0.882	0.823
Water cooled chillers > 300 Tons	National Grid	0.762	0.765
All	WMECO	0.80	0.80
All	CLC	Site Specific	Site Specific

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) 2009 until 1/1/2014, and the IECC 2012 after 1/1/2014. Table 21 details the specific efficiency requirements by equipment type and capacity.

Table 21: Water Chilling Packages - Minimum Efficiency Requirements[438]

Equipment Type	Size Category (Tons)	Units	Path A		Path B	
			Full Load	IPLV	Full Load	IPLV
Air-cooled chillers	< 150	EER	9.562	12.5	NA	NA
	≥ 150	EER	9.562	12.75	NA	NA
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 75	kW/ton	0.780	0.63	0.800	0.600
	≥ 75 and < 150	kW/ton	0.775	0.615	0.790	0.586
	≥ 150 and < 300	kW/ton	0.680	0.580	0.718	0.540
	≥ 300	kW/ton	0.620	0.540	0.639	0.490
Water cooled, electrically operated, centrifugal	< 150	kW/ton	0.634	0.596	0.639	0.450
	≥ 150 and < 300	kW/ton	0.634	0.596	0.639	0.450
	≥ 300 and < 600	kW/ton	0.576	0.549	0.600	0.400
	≥ 600	kW/ton	0.570	0.539	0.590	0.400

Note: Compliance with this standard may be obtained by meeting the minimum requirements of Path A or B, however, both the Full Load and IPLV must be met to fulfill the requirements of Path A or B.

[436] National Grid load factors based on 1994 study.
[437] WMECO load factors based on staff estimates.
[438] International Code Council (2009). *2009 International Energy Conservation Code*;.Table 503.2.3(7). NOTE: values equal to IECC 2012 values: International Code Council (2012). *2012 International Energy Conservation Code*; Page C-46, Table C403.2.3(7).

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. Energy and demand savings calculations are based on actual equipment efficiencies should be determined on a case-by-case basis.

Hours

The equivalent full load hours of operation for water chilling packages are site-specific and should be determined on a case-by-case basis. If site-specific EFLH is unavailable, refer to the default hours presented in Appendix A: Table 60.

Measure Life

The measure life is 23 years.[439]

Secondary Energy Impacts

There are no secondary energy impacts counted for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Chillers	NC	National Grid	1.00	1.00	1.04	1.00	1.00	1.00	0.00	n/a	n/a
Chillers	NC	NSTAR, CLC	1.00	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
Chillers	NC	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	0.00	n/a	n/a
Chillers	NC	WMECO	1.00	1.00	0.91	1.09	1.57	0.82	0.05	custom	custom

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
- National Grid energy RRs based on a 1994 study of hvac and process cooling equipment.[440]
- NSTAR, CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[441]
- Unitil: energy and demand RRs are 100% for all C&I New Construction projects based on no evaluations

[439] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[440] The Fleming Group (1994). *Persistence of Commercial/Industrial Non-Lighting Measures, Volume 2, Energy Efficient HVAC and Process Cooling Equipment*. Prepared for New England Power Service Company.
[441] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.

- WMECO: Energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[442], demand RRs from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors

- National Grid: CFs estimated based on 1993-1994 evaluation research and engineering estimates.
- NSTAR, CLC, Unitil, WMECO: on-peak CFs based on standard assumptions.
- Unitil CFs set to 1.0 for summer and 0.0 for winter since no space cooling savings during winter.
- WMECO: seasonal CFs are custom calculated.

[442] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

HVAC – Hotel Occupancy Sensors

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: The measure is to the installation of hotel occupancy sensors (HOS) to control packaged terminal AC units (PTACs) with electric heat, heat pump units and/or fan coil units in hotels that operate all 12 months of the year.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Program: C&I Large Retrofit, C&I Small Retrofit

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on evaluation results:

$$\Delta kWh = SAVE_{kWh}$$
$$\Delta kW = SAVE_{kW}$$

Where:

Unit	=	Installed hotel room occupancy sensor
$SAVE_{kWh}$	=	Average annual kWh reduction per unit: 438 kWh[443]
$SAVE_{kW}$	=	Average annual kWh reduction per unit: 0.09 kW[444]

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.

[443] MassSave (2010). *Energy Analysis: Hotel Guest Occupancy Sensors*. Prepared for National Grid and NSTAR.
[444] Ibid.

Hours

Not applicable.

Measure Life

For retrofit applications, the measure life is 10 years.[445]

Secondary Energy Impacts

There are no secondary energy impacts.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
HOS	Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.30	0.70	n/a	n/a
HOS	Large Retrofit	NSTAR, CLC	1.00	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a
HOS	Large Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.82	0.05	n/a	n/a
HOS	Large Retrofit	WMECO	1.00	1.00	0.91	1.09	1.57	0.82	0.05	0.00	0.00
HOS	Small Retrofit	CLC	1.00	1.00	1.01	1.09	1.57	0.82	0.05	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
- National Grid: RRs based on engineering estimates.
- NSTAR, CLC energy and demand RRs from impact evaluation of NSTAR 2006 HVAC installations[446]
- Unitil: Energy and demand RRs are 100% based on no evaluations.
- WMECO: Energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[447], demand RRs from impact evaluation of NSTAR 2006 HVAC installations referenced above.

Coincidence Factors
- National Grid: CFs based on engineering estimates.
- NSTAR, CLC, Unitil, WMECO: on-peak CFs based on standard assumptions.
- WMECO: seasonal CFs set to 0.00 based on assumption that no savings occur during seasonal peak periods.

[445] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1; Measure life is assumed to be the same as for EMS retrofit measure.
[446] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[447] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

HVAC – Programmable Thermostats

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure involves the installation of a programmable thermostat for cooling and/or heating systems in spaces with either no or erratic existing control.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (SQFT)(SAVE_{kWh})$$
$$\Delta kW = (SQFT)(SAVE_{kW})$$

Where:
SQFT = Square feet of controlled space
$SAVE_{kWh}$ = Average kW reduction per SQFT of controlled space. See Table 22.
$SAVE_{kW}$ = Average annual kWh reduction per SQFT of controlled. See Table 22.

Table 22: Savings Factors (Save)[448]

Equipment Type	$SAVE_{kWh}$ (kWh/SQFT)	$SAVE_{kW}$ (kW/SQFT)
Cool Only No Existing Control	0.539	0.00
Cool Only Erratic Existing Control	0.154	0.00
Heat Only No Existing Control	0.418	0.00
Heat Only Erratic Existing Control	0.119	0.00
Cool and Heat No Existing Control	0.957	0.00
Cool and Heat Erratic Existing Control	0.273	0.00
Heat Pump No Existing Control	0.848	0.00
Heat Pump Erratic Existing Control	0.242	0.00

Baseline Efficiency

The baseline efficiency case includes spaces with either no or erratic heating and/or cooling control as indicated in the equipment type selection.

[448] Massachusetts common assumptions.

High Efficiency

The high efficiency case includes control of the space cooling and/or heating system as indicated in the equipment type selection.

Hours

Not applicable.

Measure Life

For retrofit applications, the measure life is 8 years.[449]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Thermostats	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Thermostats	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Thermostats	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Thermostats	Small Retrofit	WMECO	1.00	1.00	1.00	0.92	0.92	0.00	0.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs set to 100% based on no evaluations.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program[450], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
-

Coincidence Factors
- All PAs CFs set to zero since no savings are expected during peak periods.

[449] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[450] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Door Heater Controls

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of controls to reduce the run time of door and frame heaters for freezers and walk-in or reach-in coolers. The reduced heating results in a reduced cooling load.[451]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = kW_{DH} * \%OFF * 8760$$
$$\Delta kW = kW_{DH} * \%OFF$$

Where:

kW_{DH}	=	Total demand of the door heater, calculated as Volts * Amps / 1000
8760	=	Door heater annual run hours before controls
%OFF		Door heater Off time[452]: 46% for freezer door heaters or 74% for cooler door heaters)

Baseline Efficiency

The baseline efficiency case is a cooler or freezer door heater that operates 8,760 hours per year without any controls.

High Efficiency

The high efficiency case is a cooler or freezer door heater connected to a heater control system, which controls the door heaters by measuring the ambient humidity and temperature of the store, calculating the dewpoint, 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 dewpoint temperature.[453]

[451] The assumptions and algorithms used in this section are specific to NRM products.
[452] 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.
[453] Select Energy Services, Inc. (2004). *Analysis of Cooler Control Energy Conservation Measures*. Prepared for NSTAR.

Hours

Pre-retrofit hours are 8,760 hours per year. After controls are installed, the door heaters in freezers are on for an average 4,730.4 hours/year (46% off time) and the door heaters for coolers are on for an average 2,277.6 hours/year (74% off time).

Measure Life

The measure life for cooler and freezer door heater controls is 10 years.[454]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Door Heater Control	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.50	1.00	n/a	n/a
Door Heater Control	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	0.50	1.00	n/a	n/a
Door Heater Control	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.50	1.00	n/a	n/a
Door Heater Control	Small Retrofit	WMECO	1.00	1.00	0.86	0.92	0.92	0.50	1.00	0.10	0.10

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid: energy RR based on staff estimates.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program.[455], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
- All PAs: on-peak CFs from the 1995 HEC study of walk-in cooler anti-sweat door heater controls.[456]
- WMECO: seasonal CFs based on staff estimates.

[454] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[455] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.
[456] HEC, Inc. (1995). *Analysis of Door Master Walk-In Cooler Anti-Sweat Door Heater Controls Installed at Ten Sites in Massachusetts*. Prepared for New England Power Service Company; Table 9. Adjusted to account for updated RR.

Refrigeration – Novelty Cooler Shutoff

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of controls to shut off a facility's novelty coolers for non-perishable goods based on pre-programmed store hours. Energy savings occur as coolers cycle off during facility unoccupied hours.[457]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (kW_{NC})(DC_{AVG})(HoursOFF)$$
$$\Delta kW = 0$$

Where:

ΔkW	=	0 since savings are assumed to occur during evening hours and are therefore not coincident with either summer or winter peak periods.
kW_{NC}	=	Power demand of novelty cooler calculated from equipment nameplate data and estimated 0.85 power factor[458]
HoursOFF	=	Potential hours off every night per year, estimated as one less than the number of hours the store is closed per day
DC_{AVG}	=	Weighted average annual duty cycle: 48.75%[459]

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.

[457] The assumptions and algorithms used in this section are specific to NRM products.
[458] Conservative value based on 15 years of NRM field observations and experience.
[459] Ibid; the estimated duty cycles for Novelty Coolers are supported by Select Energy Services, Inc. (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual.* Prepared for NSTAR. The study gives a less conservative value than used by NRM.

Hours

Energy and demand savings are based on the reduced operation hours of the cooler equipment. Hours reduced per day are estimated on a case-by-case basis, and are typically calculated as one less than the number of hours per day that the facility is closed each day.

Measure Life

The measure life is 10 years.[460]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SP}	CF_{WP}
Novelty Cooler Shutoff	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Novelty Cooler Shutoff	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Novelty Cooler Shutoff	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Novelty Cooler Shutoff	Small Retrofit	WMECO	1.00	1.00	0.86	0.92	0.92	0.00	0.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid: energy RR based on staff estimates.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program.[461], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off-peak hours.

[460] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[461] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – ECM Evaporator Fan Motors for Walk–in Coolers and Freezers

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of various sizes of electronically commutated motors (ECMs) in walk-in coolers and freezers to replace existing evaporator fan motors.[462]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Fan} = kW_{Fan} * LRF * Hours$$
$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / 8{,}760$$

Where:

ΔkWh_{Fan}	=	Energy savings due to increased efficiency of evaporator fan motor
ΔkWh_{Heat}	=	Energy savings due to reduced heat from the evaporator fans
kW_{Fan}	=	Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/adjustment[463]: Amps x Voltage x PF x √Phase
LRF	=	Load reduction factor for motor replacement (65%)[464]
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[465]
ΔkW	=	Average demand savings
8,760	=	Hours per year

[462] The assumptions and algorithms used in this section are specific to NRM products.
[463] Conservative value based on 15 years of NRM field observations and experience.
[464] 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.
[465] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

Baseline Efficiency

The baseline efficiency case is an existing evaporator fan motor.

High Efficiency

The high efficiency case is the replacement of existing evaporator fan motors with ECMs.

Hours

The annual operating hours are assumed to be 8,760 * (1-%OFF), where %OFF = 0 if the facility does not have evaporator fan controls or %OFF = 46% if the facility has evaporator fan controls (4,030 hours). See section: Refrigeration – Evaporator Fan Controls for more on %OFF value.

Measure Life

The measure life is 15 years.[466]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings[467]

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Evap Fan ECMs	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan ECMs	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Evap Fan ECMs	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan ECMs	Small Retrofit	WMECO	1.00	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid: RRs set to 100% since changes to calculation methodology made based on 2005 Custom SBS program evaluation. [468]
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.

[466] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.
[467] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation.* Prepared for National Grid.
[468] RLW Analytics (2007). *Impact Evaluation Analysis of the 2005 Custom SBS Program*. Prepared for National Grid.

- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program[469], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors

All: CFs set to 1 since demand savings are average

[469] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008.* Prepared for Western Massachusetts Electric Company.

Refrigeration – Case Motor Replacement

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of electronically commutated motors (ECMs) in multi-deck and freestanding coolers and freezers, typically on the retail floor of convenience stores, liquor stores, and grocery stores.[470]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = \Delta kWh_{Motor} + \Delta kWh_{Heat}$$
$$\Delta kWh_{motor} = kW_{Motor} * LRF * Hours$$
$$\Delta kWh_{heat} = \Delta kWh_{Motor} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / 8{,}760$$

Where:

ΔkWh_{Motor}	=	Energy savings due to increased efficiency of case motor
ΔkWh_{Heat}	=	Energy savings due to reduced heat from evaporator fans
kW_{motor}	=	Metered load of case motor
LRF	=	Load reduction factor: 53% when shaded pole motors are replaced, 29% when PSC motors are replaced[471]
Hours	=	Average runtime of case motors (8,500 hours)[472]
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) [473]
ΔkW	=	Average demand savings
8,760	=	Hours per year

[470] The assumptions and algorithms used in this section are specific to NRM products.
[471] Load factor is an estimate by NRM based on several pre- and post-meter readings of installations
[472] Conservative value based on 15 years of NRM field observations and experience.
[473] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

Baseline Efficiency

The baseline efficiency case is the existing case motor.

High Efficiency

The high efficiency case is the replacement of the existing case motor with an ECM.

Hours

Hours are the annual operating hours of the case motors.

Measure Life

The measure life is 15 years.[474]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Case ECMs	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Case ECMs	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Case ECMs	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Case ECMs	Small Retrofit	WMECO	1.00	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid: RRs set to 100% since changes to calculation methodology made based on 2005 Custom SBS program evaluation. [475]
- Unitil: RRs set to 100% based on no evaluations.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program[476], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

[474] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.
[475] RLW Analytics (2007). *Impact Evaluation Analysis of the 2005 Custom SBS Program*. Prepared for National Grid.

Coincidence Factors

All: CFs set to 1 since demand savings are average

[476] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008.* Prepared for Western Massachusetts Electric Company.

Refrigeration – Cooler Night Covers

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of retractable aluminum woven fabric covers for open-type refrigerated display cases, where the covers are deployed during the facility unoccupied hours in order to reduce refrigeration energy consumption.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (Width)(Save)(Hours)$$
$$\Delta kW = (Width)(Save)$$

Where:
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 23.
Hours = Annual hours that the night covers are in use

Table 23: Savings Factors[477]

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.

[477] 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*.

Hours

Hours represent the number of annual hours that the night covers are in use, and should be determined on a case-by-case basis.

Measure Life

The measure life is 10 years.[478]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Cooler Night Cover	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Cooler Night Cover	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Cooler Night Cover	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Cooler Night Cover	Small Retrofit	WMECO	1.00	1.00	0.86	0.92	0.92	0.00	0.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs set to 100% based on no evaluations.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program.[479] Demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
Coincidence factors are set to zero since demand savings typically occur during off-peak hours.

[478] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Page 4-5 to 4-6.
[479] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Electronic Defrost Control

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: A control mechanism to skip defrost cycles when defrost is unnecessary.[480]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = \Delta kWh_{Defrost} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Defrost} = kW_{Defrost} * Hours * DRF$$
$$\Delta kWh_{Heat} = \Delta kWh_{Defrost} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / 8{,}760$$

Where:

$\Delta kWh_{Defrost}$	=	Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls.
ΔkWh_{Heat}	=	Energy savings due to reduced heat from reduced number of defrosts.
$kW_{Defrost}$	=	Load of electric defrost.
Hours	=	Number of hours defrost occurs over a year without the defrost controls.
DRF	=	Defrost reduction factor- percent reduction in defrosts required per year (35%)[481]
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)[482]
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.

[480] The assumptions and algorithms used in this section are specific to NRM products.
[481] Ibid; supported by 3rd party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability.
[482] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR.

High Efficiency

The high efficiency case is an evaporator fan defrost system with electric defrost controls.

Hours

The number of defrost cycles is estimated to decrease by 35% from an average number of defrost cycles of 1460 defrosts/year at 40 minutes each for a total of 973 hours/year.[483] The number of defrost cycles with the defrost controls is 949 cycles/year, or 633 hours/year.

Measure Life

The measure life is 10 years.[484]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Defrost Control	Small Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Defrost Control	Small Retrofit	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Defrost Control	Small Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Defrost Control	Small Retrofit	WMECO	1.00	1.00	0.86	0.92	0.92	1.00	1.00	1.00	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs set to 100% based on no evaluations.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program.[485], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
- All: CFs set to 1 since demand savings are average

[483] Conservative value based on 15 years of NRM field observations and experience.
[484] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities.
[485] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Evaporator Fan Controls

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of controls to modulate the evaporator fans based on temperature control. Energy savings include: fan energy savings from reduced fan operating hours, refrigeration energy savings from reduced waste heat, and compressor energy savings resulting from the electronic temperature control. Electronic controls allow less fluctuation in temperature, thereby creating savings.[486]
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat} + \Delta kWh_{Control}$$

$$\Delta kWh_{Fan} = kW_{Fan} * 8760 * \%OFF$$

$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$

$$\Delta kWh_{Control} = \left[kW_{CP} * Hours_{CP} + kW_{Fan} * 8760 * (1 - \%Off)\right] * 5\%$$

$$\Delta kW = \Delta kWh / 8760$$

[486] The assumptions and algorithms used in this section are specific to NRM products.

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[487]: Amps x Voltage x PF x √Phase
%OFF	=	Percent of annual hours that the evaporator is turned off: 46%[488]
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[489]
kW_{CP}	=	Total power demand of compressor motor and condenser fan calculated from equipment nameplate data and estimated 0.85 power factor[490]: Amps x Voltage x PF x √Phase
$Hours_{CP}$	=	Equivalent annual full load hours of compressor operation: 4,072 hours[491]
5%	=	Reduced run-time of compressor and evaporator due to electronic temperature controls[492]
ΔkW	=	Average demand savings
8,760	=	Hours per year

Baseline Efficiency

The baseline efficiency case assumes evaporator fans that run 8760 annual hours with no temperature control.

High Efficiency

The high efficiency case is the use of an energy management system to control evaporator fan operation based on temperature.

Hours

The operation of the fans is estimated to be reduced by 46% from the 8,760 hours in the base case scenario.

Measure Life

The measure life is 10 years[493].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[487] Conservative value based on 15 years of NRM field observations and experience.
[488] 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.
[489] 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.
[490] This value is an estimate by NRM based on hundreds of downloads of hours of use data from the electronic controller.
[491] Conservative value based on 15 years of NRM field observations and experience.
[492] 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.
[493] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Evap Fan Control	Small Retrofit	National Grid	1	1	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan Control	Small Retrofit	NSTAR, CLC	1	1	0.91	0.92	0.92	1.00	1.00	n/a	n/a
Evap Fan Control	Small Retrofit	Unitil	1	1	1.00	1.00	1.00	1.00	1.00	n/a	n/a
Evap Fan Control	Small Retrofit	WMECO	1	1	0.86	0.92	0.92	1.00	1.00	1.00	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid set to 100% after small retrofit RRs from 1996 savings analysis[494] suggestions for more accurate calculations adopted.
- NSTAR, CLC: RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.
- Unitil: RRs set to 100% based on no evaluations.
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program[495], demand RRs based on NSTAR 2002-2004 small retrofit program impact evaluations.

Coincidence Factors
- All: CFs set to 1 since demand savings are average

[494] HEC, Inc. (1996). *Analysis of Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls*. Prepared for New England Power Service Company.
[495] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.

Refrigeration – Vending Misers

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Controls can significantly reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Retrofit
End Use: Refrigeration
Program: C&I Large Retrofit, C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

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

$$\Delta kWh = (kW_{RATED})(Hours)(SAVE)$$
$$\Delta kW = \Delta kWh / Hours$$

Where:

kW_{rated}	=	Rated kW of connected equipment. See Table **24** 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 **24** for values.

Table 24: Vending Machine and Cooler Controls Savings Factors [496]

Equipment Type	kWRATED	SAVE (%)	ΔkW	ΔkWh
Refrigerated Beverage Vending Machines	0.40	46	0.184	1612
Non-Refrigerated Snack Vending Machines	0.085	46	0.039	343
Glass Front Refrigerated Coolers	0.46	30	0.138	1208

[496] USA Technologies Energy Management Product Sheets (2006). http://www.usatech.com/energy_management/energy_productsheets.php. Accessed 9/1/09.

Baseline Efficiency

The baseline efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

High Efficiency

The high efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Hours

It is assumed that the connected equipment operates 24 hours per day, 7 days per week for a total annual operating hours of 8,760.

Measure Life

The measure life is 5 years.[497]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

[497] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Vending Misers	Large Retrofit	National Grid	1	1	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	National Grid	1	1	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	NSTAR	1	1	0.85	0.41	0.24	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	NSTAR	1	1	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	CLC	1	1	0.85	0.41	0.24	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	CLC	1	1	0.91	0.92	0.92	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	Unitil	1	1	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Small Retrofit	Unitil	1	1	1.00	1.00	1.00	0.00	0.00	n/a	n/a
Vending Misers	Large Retrofit	WMECO	1	1	0.91	0.41	0.24	0.00	0.00	0.00	0.00
Vending Misers	Small Retrofit	WMECO	1	1	0.86	0.92	0.92	0.00	0.00	0.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs set to 100% since savings estimated are based on study results.
- NSTAR, CLC: large retrofit RRs from impact evaluation of NSTAR 2006 refrigeration installations[498]; small retrofit RRs from impact evaluation of 2002 program year[499]
- WMECO: Energy RRs from impact evaluation of 2008 small retrofit program[500]; large retrofit energy RRs are based on end use from 2007/2008 Large C&I Programs impact evaluation[501], large retrofit demand RRs from impact evaluation of NSTAR 2006 refrigeration installations, small retrofit demand RRs from NSTAR impact evaluation of 2002 program year

Coincidence Factors
- All PAs: CFs based on staff estimates- assumed that savings occur during off peak hours.

[498] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[499] RLW Analytics (2003). *Small Business Solutions Program Year 2002 Impact Evaluation - Final Report*. Prepared for NSTAR.
[500] The Cadmus Group, Inc. (2010). *Western Massachusetts Small Business Energy Advantage Impact Evaluation Report Program Year 2008*. Prepared for Western Massachusetts Electric Company.
[501] KEMA, Inc. (2011). *2007/2008 Large C&I Programs,*

Food Service – Commercial Electric Ovens

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial convection oven or commercial combination oven. ENERGY STAR® commercial ovens save energy during preheat, cooking and idle times due to improved cooking efficiency, and preheat and idle energy rates. Combination ovens can be used either as convection ovens or as steamers.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator and the Food Services Technology Center Life Cycle Cost Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See Table 25.
ΔkW = gross average kW savings from the measure. See Table 25.
Hours = Annual hours of operation. See Hours section below.

Table 25: Energy Savings for Commercial Ovens

Equipment Type	ΔkW	ΔkWh
Convection Oven[502]	0.436	1,364
Combination Oven[503]	2.579	9,688

[502] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Convection Oven Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. Default assumptions used except for hours of operation, and because of that adjustment, pounds of food cooked per day (used 80 lb/day). See Hours section below.
[503] Food Service Technology Center, Electric Combination Oven Life-Cycle Cost Calculator: http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php. Default assumptions used, except for operating hours, see Hours section below, and 10 pans to account for popularity of half size units.

Baseline Efficiency

The baseline efficiency case is a convection oven with a cooking energy efficiency of 65%, production capacity of 70 pounds per hour, preheat energy of 1.5 kWh and idle energy rate of 2.0 kW.

The baseline efficiency case for a combination oven is a commercial combination oven with a convection cooking energy efficiency of 65% with a production capacity of 80 pounds per hour for convection mode and 40% steam cooking energy efficiency, with a production capacity of 100 pounds per hour for steam mode. Preheat energy is assumed to be 3.0 kWh and the idle energy is assumed to be 3.0 kW for convection mode and 10.0 kW for steam mode.

High Efficiency

The high efficiency case is a convection oven with a cooking energy efficiency of 70%, production capacity of 80 pounds per hour, preheat energy of 1.0 kWh and idle energy rate of 1.5 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 100 pounds per hour for convection mode, and 50% cooking energy efficiency with a production capacity of 120 pounds per hour for steam mode, preheat energy of 1.5 kWh and idle energy rate of 2.0 kW for convection mode and 5.0 kW for steam mode.

Hours

Ovens assumed to operate 313 days per year.[504] Combination ovens assumed to operate 12 hours a day, or 3,756 hours.[505] Convection ovens assumed to operate 10 hours a day, or 3,130 hours.[506]

Measure Life

The measure life for a new commercial electric oven is 12 years[507].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

[504] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[505] Food Service Technology Center, Electric Combination Oven Life-Cycle Cost Calculator: *http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php*.
[506] Value represents compromised between hours given in ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Convection Oven Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. AND Technical Assessment of Commercial Ovens <http://www.fishnick.com/equipment/techassessment/7_ovens.pdf>, pg 23.
[507] Pacific Gas & Electric Company – Customer Energy Efficiency Department (2007). *Work Paper PGECOFST101, Commercial Convection Oven, Revision #0.*

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Ovens	NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR® and FTCS.

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.

Food Service – Commercial Electric Steam Cooker

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial steam cooker. ENERGY STAR® steam cookers save energy during cooling and idle times due to improved cooking efficiency and idle energy rates.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Water, Wastewater
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = (SAVE)(Quantity)(Hours)$$
$$\Delta kW = (SAVE)(Quantity)$$ Where:

ΔkWh = gross annual kWh savings from the measure. With default Quantity, average savings are 8,381 kWh.
ΔkW = average kW savings from the measure. With default Quantity, average savings are 2.231 kW
SAVE = Demand savings per pan: 0.744 kW/pan [508]
Quantity = Number of pans. Default of 3 pans.
Hours = Average annual equipment operating hours. See Hours section below.

Baseline Efficiency

The Baseline Efficiency case is an electric steam cooker with a cooking efficiency of 30%, pan production capacity of 16.7 pounds per hour, preheat energy of 1.5 kWh, and idle energy rate of 1.2 kW.

High Efficiency

The High Efficiency case is an ENERGY STAR® electric steam cooker with a cooking energy efficiency of 50%, pan production capacity of 23.3 pounds per hour, preheat energy of 1.5 kWh, and an idle energy rate of 0.4 kW.

[508] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Steam Cooker Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* > except for hours of operation, see Hours section below.

Hours

Steamers are assumed to operate 313 days per year.[509] The average steam cooker is assumed to operate 12 hours per day[510], or 3,756 hours per year.

Measure Life

The measure life for a new steamer is 12 years.[511]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Water and wastewater is saved due to the improved cooking efficiency of the high efficiency equipment.

Benefit Type	Description	Savings[512]
C&I Water	Annual water savings per unit	139,000 gallons/unit
C&I Waste Water	Annual wastewater savings per unit	139,000 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Steam Cooker	NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[509] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[510] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Steam Cooker Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >
[511] Ibid.
[512] Ibid.

Food Service – Commercial Electric Griddle

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® griddle. ENERGY STAR® griddles save energy during preheat, cooking and idle times due to improved cooking efficiency, and preheat and idle energy rates.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = (SAVE)(Width)(Hours)$$
$$\Delta kW = (SAVE)(Width)$$

Where:

ΔkWh	=	gross annual kWh savings from the measure. With default Width, average savings are 2,226 kWh.
ΔkW	=	gross average kW savings from the measure. With default Width, average savings are 0.593 kW.
SAVE	=	Savings per foot of griddle width: 0.198 kW/ft[513]
Width	=	Width of griddle in feet. Default of 3 feet.
Hours	=	Average annual equipment operating hours, see Hours section below.

Baseline Efficiency

The baseline efficiency case is a typically sized, 6 sq. ft. commercial griddle with a cooking energy efficiency of 65%, production capacity of 35 pounds per hour, preheat energy of 2,667 W/sq. ft. and idle energy rate of 400 W/sq. ft.

[513] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Griddle Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >

High Efficiency

The high efficiency case is a typically sized, 6 sq. ft. commercial griddle with a cooking energy efficiency of 70%, production capacity of 40 pounds per hour, preheat energy of 1,333 W/ sq. ft. and idle energy rate of 320 W/sq. ft.

Hours

Griddles are assumed to operate 313 days per year.[514] The average griddle is assumed to operate 12 hours per day[515], or 3,756 hours per year.

Measure Life

The measure life for a new griddle is 12 years.[516]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Griddle	NC	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[514] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[515] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Steam Cooker Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >
[516] PG&E calculator: http://www.fishnick.com/saveenergy/tools/calculators/egridcalc.php

Food Service – Low Temperature Commercial Dishwasher

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® low temperature commercial dishwasher. Low temperature dishwashers use the hot water supplied by the kitchen's existing water heater and use a chemical sanitizing agent in the final rinse cycle and sometimes a drying agent.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Water
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See Table 26
ΔkW = gross average kW savings from the measure. See Table 26
Hours = Average annual equipment operating hours, see Hours section below.

Table 26: Energy Savings for Low Temperature Commercial Dishwashers[517]

Equipment Type	ΔkW	ΔkWh
Under Counter	0.185	1,040
Door Type	1.847	10,406
Single Tank Conveyor	1.733	9,763

Baseline Efficiency

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

[517] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Dishwasher Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. Default values used except for days operated per year. See Hours section below.

Dishwasher Type	Idle Energy Rate	Water Consumption
Under Counter	0.15 kW	1.95 gal/rack
Door Type	0.12 kW	1.85 gal/rack
Single Tank Conveyor	0.69 kW	1.23 gal/rack

High Efficiency

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

Dishwasher Type	Idle Energy Rate	Water Consumption
Under Counter	<= 0.5 kW	<= 1.70 gal/rack
Door Type	<= 0.6 kW	<= 1.18 gal/rack
Single Tank Conveyor	<= 1.6 kW	<= 0.790 gal/rack

Hours

Dishwashers are assumed to operate 313 days per year.[518] The average dishwasher is assumed to operate 18 hours per day[519], or 5,634 hours per year.

Measure Life

The measure life for a new low temperature dishwasher is given by type below:[520]

Dishwasher Type	Life (years)
Under Counter	10
Door Type	15
Single or Multi Tank Conveyor	20

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are water savings associated with this measure:[521]

Dishwasher Type	Annual water savings per unit	Annual wastewater savings per unit	Units
Under Counter	5,869	5,869	Gallons/unit
Door Type	58,719	58,719	Gallons/unit
Single Tank Conveyor	55,088	55,088	Gallons/unit

[518] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[519] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Dishwasher Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >
[520] Ibid.
[521] Ibid.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low Temperature Dishwasher	NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Food Service – High Temperature Commercial Dishwasher

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® high temperature commercial dishwasher in a building with gas domestic hot water. High temperature dishwashers use a booster heater to raise the rinse water temperature to 180 deg F – hot enough to sterilize dishes and assist in drying. Electric savings are achieved through savings to the electric booster.
Primary Energy Impact: Electric
Secondary Energy Impact: Gas
Non-Energy Impact: Water
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See Table 27
ΔkW = gross average kW savings from the measure. See Table 27
Hours = Average annual equipment operating hours, see Hours section below.

Table 27: Energy Savings for High Temperature Commercial Dishwashers[522]

Equipment Type	ΔkW	ΔkWh
Under Counter	0.414	2,330
Door Type	0.802	4,518
Single Tank Conveyor	1.234	6,954

Baseline Efficiency

The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows:

[522] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Dishwasher Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. Default values used except for days operated per year. See Hours section below.

Dishwasher Type	Idle Energy Rate	Water Consumption
Under Counter	0.42 kW	1.98 gal/rack
Door Type	0.58 kW	1.44 gal/rack
Single Tank Conveyor	2.3 kW	1.13 gal/rack

High Efficiency

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

Dishwasher Type	Idle Energy Rate	Water Consumption
Under Counter	<= 0.90 kW	<= 1.00 gal/rack
Door Type	<= 1.0 kW	<= 0.950 gal/rack
Single Tank Conveyor	<= 2.0 kW	<= 0.700 gal/rack

Hours

Dishwashers are assumed to operate 313 days per year.[523] The average dishwasher is assumed to operate 18 hours per day[524], or 5,634 hours per year.

Measure Life

The measure life for a new high temperature dishwasher is given by type below:[525]

Dishwasher Type	Life (years)
Under Counter	10
Door Type	15
Single or Multi Tank Conveyor	20

Secondary Energy Impacts

There are gas savings for this measure.

Dishwasher Type	Savings (therms)
Under Counter	189
Door Type	353
Single Tank Conveyor	442

Non-Energy Impacts

There are water savings associated with this measure:[526]

[523] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[524] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Dishwasher Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >
[525] Ibid.
[526] Ibid.

Dishwasher Type	Annual water savings per unit	Annual wastewater savings per unit	Units
Under Counter	23,006	23,006	Gallons/unit
Door Type	42,944	42,944	Gallons/unit
Single Tank Conveyor	53,836	53,836	Gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
High Temperature Dishwasher	NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Food Service – Commercial Ice Machine

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial ice machine. Commercial ice machines meeting the ENERGY STAR® specifications are on average 15 percent more energy efficient and 10 percent more water-efficient than standard models. Air-cooled, cube-type machines are eligible for ENERGY STAR® qualification, including ice-making head (IMH), self-contained (SCU), and remote condensing units (RCU).
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: Water
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure. See Table 28
ΔkW = gross average kW savings from the measure. See Table 28
Hours = Average annual equipment operating hours, see Hours section below.

Table 28: Energy Savings for Commercial Ice Machine[527]

Equipment Type	ΔkW	ΔkWh
Ice Making Head	0.073	638
Self Contained Unit	0.079	690
Remote Condensing Unit	0.019	170

Baseline Efficiency

The baseline efficiency case is a non-ENERGY STAR® commercial ice machine.

[527] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Commercial Ice Machine Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. Except for duty cycle of machines- ES tool uses 75% duty cycle, which is thought to be too high. Duty cycle of 40% used instead.

High Efficiency

The high efficiency case is a commercial ice machine meeting the ENERGY STAR® Efficiency Requirements as noted in the table below:

Equipment Type	Daily Ice Harvest Rate, H (lbs ice/day)	Energy Use Limit (kWh/100 lbs ice)	Potable Water Use Limit (gal/100 lbs ice)
Ice Making Head	<450	9.23 – 0.0077H	<=25
	>=450	6.20 – 0.0010H	<=25
Self Contained Unit	<1000	8.05 – 0.0035H	<=25
	>=1000	4.64	<=25
Remote Condensing Unit	<934	8.05 – 0.0035H	<=25
	>=934	4.82	<=25

Hours

Ice making machines are assumed to operate 365 days per year. The average ice making machine is assumed to operate 18 hours per day[528], or 5,634 hours per year.

Measure Life

The measure life for a new ice making machine is assumed to be 8 years.[529]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are water savings associated with this measure:[530]

Dishwasher Type	Annual water savings per unit	Annual wastewater savings per unit	Units
Ice Making Head	588	588	Gallons/unit
Self Contained Unit	2,264	2,264	Gallons/unit
Remote Condensing Unit	736	736	Gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Ice Making Machine	NC	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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

[528]ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Commercial Ice Machine Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >
[529] Ibid.
[530] Ibid.

Savings Persistence Factor

All PAs use 100% savings persistence factor.

Realization Rates

100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors

Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Food Service – Commercial Fryers

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® commercial fryer. ENERGY STAR® commercial fryers save energy during preheat, cooking and idle times due to improved cooking efficiency, and preheat and idle energy rates.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kW / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure: 760 kWh[531]
ΔkW = gross average kW savings from the measure: 0.202 kW[532]
Hours = Annual hours of operation. See Hours section below.

Baseline Efficiency

The baseline efficiency case is a deep-fat fryer with a cooking energy efficiency of 75%, shortening capacity of up to 65 pounds, daily preheat energy of 2.3 kWh and idle energy rate of 1.05 kW.

High Efficiency

The high efficiency case is a deep-fat fryer with a cooking energy efficiency of 80%, shortening capacity of up to 65 pounds, daily preheat energy of 1.7 kWh, and idle energy rate of no more than 1.0 kW. For large-capacity fryers (shortening capacity exceeds 50 pounds), the idle energy rate may be up to 1.1 kW.

[531] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: Fryer Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. Default assumptions used except for operating hours, see Hours section, and food cooked per day. Food cooked is adjusted based on the reduction in operating hours.
[532] Ibid.

Hours

Fryers assumed to operate 313 days per year.[533] Fryers assumed to operate 12 hours a day, or 3,756 hours per year.[534]

Measure Life

The measure life for a new commercial electric fryer is 12 years[535].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Electric Fryer	NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[533] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[534] Default hours of 16 seem excessive by staff estimates and compared to other commercial equipment operation hours. Twelve hours used as more reasonable estimate.
[535] Pacific Gas & Electric Company – Customer Energy Efficiency Department (2007). *Work Paper PGECOFST101, Commercial Convection Oven, Revision #0.*

Food Service – Food Holding Cabinets

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of a qualified ENERGY STAR® hot food holding cabinet (HFHC). ENERGY STAR® hot food holding cabinets are 65 percent more energy efficient than standard models. Models that meet this requirement incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door gaskets, auto-door closures, or dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. Offering full size, ¾ size, and ½ half size HFHC.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial
Market: Lost Opportunity
End Use: Food Service
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impacts

Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator:

$$\Delta kWh = \Delta kWh$$
$$\Delta kW = \Delta kWh / Hours$$

Where:
ΔkWh = gross annual kWh savings from the measure: See Table 29
ΔkW = gross average kW savings from the measure: See Table 29
Hours = Annual hours of operation. See Hours section below.

Table 29: Energy Savings for Commercial Hot Food Holding Cabinets[536]

Equipment Type	ΔkW	ΔkWh
Full Size	1.700	7,982
¾ Size	0.720	3,380
½ Size	0.480	2,254

Baseline Efficiency

The baseline efficiency case for a HFHC is 125 W/cubic ft for full size and 100 W/cubic ft for ¾ and ½ size.

[536] ENERGY STAR® Commercial Kitchen Equipment Savings Calculator: HFHC Calculations. < *http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/commercial_kitchen_equipment_calculator.xls* >. Default assumptions used except for hours of operation. See Hours section below.

High Efficiency

The high efficiency case for HFHC is 40 W/cubic ft for all sizes.

Hours

Hot food holding cabinets assumed to operate 313 days per year.[537] HFHC assumed to operate 15 hours a day, or 4,695 hours per year.[538]

Measure Life

The measure life for a new commercial HFHC is 12 years[539].

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
HFHC	NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
100% realization rates are assumed because savings are based on researched assumptions by ENERGY STAR®.

Coincidence Factors
Coincidence factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

[537] The default value of 365 days per year seems excessive. Though many or most restaurants operate 7 days per week, many institutional kitchens do not. 6 day operation is assumed. 365 * 6/7 = 313 days/yr
[538] Default hours of 16 seem excessive by staff estimates and compared to other commercial equipment operation hours. Twelve hours used as more reasonable estimate.
[539] Pacific Gas & Electric Company – Customer Energy Efficiency Department (2007). *Work Paper PGECOFST101, Commercial Convection Oven, Revision #0.*

Compressed Air – High Efficiency Air Compressors

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: Covers the installation of oil flooded, rotary screw compressors with Load/No Load, Variable Speed Drive, or Variable Displacement capacity control with properly sized air receiver. Efficient air compressors use various control schemes to improve compression efficiencies at partial loads. When an air compressor fitted with Load/No Load, Variable Speed Drive, or Variable Displacement capacity controls is used in conjunction with a properly-sized air receiver, considerable amounts of energy can be saved.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Compressed Air
Program: C&I New Construction, C&I Large Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (HP_{COMPRESSOR})(SAVE)(Hours)$$
$$\Delta kW = (HP_{COMPRESSOR})(SAVE)$$

Where:
$HP_{COMPRESSOR}$ = Nominal rated horsepower of high efficiency air compressor.
Save = Air compressor kW reduction per HP. See Table 30 for values.
Hours = Annual operating hours of the air compressor.

Table 30: Air Compressor kW Reduction per Horsepower

Control Type	Nominal Horsepower (HP)	kW Reduction per Horsepower (Save)[540]	
		Lost Opportunity	Retrofit
Load/No Load	≥15 and <25	0.076	0.102
Load/No Load	≥25 and <=75	0.114	0.102
VSD	≥15 and <25	0.159	0.207
VSD	≥25 and <=75	0.228	0.206
Variable Displacement	≥50 and <=75	0.110	0.116

[540] From NSTAR analysis based on metering data. The location of original data and analysis is unknown; however, these values are supported by multiple 3rd party impact evaluations.

Baseline Efficiency

The baseline efficiency case is a typical modulating compressor with blow down valve.

High Efficiency

The high efficient case is an oil-flooded, rotary screw compressor with Load/No Load, 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.

Hours

The annual hours of operation for air compressors are site-specific and should be determined on a case-by-case basis.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 15 years. For retrofit projects, the lifetime is 13 years.[541]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Air Compressor	NC, Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Air Compressor	NC, Large Retrofit	NSTAR, CLC	1.00	1.00	1.25	0.95	0.80	0.88	0.69	n/a	n/a
Air Compressor	NC, Large Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Air Compressor	NC, Large Retrofit	WMECO	1.00	1.00	0.90	0.95	0.80	0.88	0.69	0.77	0.54

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

[541] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Realization Rates

- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[542]
- NSTAR, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[543]
- WMECO: energy RRs are from 2007/2008 Large C&I Programs impact evaluation[544], demand RRs from impact evaluation of NSTAR 2006 compressed air installations referenced above.

Coincidence Factors

- National Grid, Unitil, WMECO: seasonal CFs based on impact evaluation of PY 2004 compressed air installations.[545]
- NSTAR, CLC, WMECO: on-peak CFs based on standard assumptions.

[542] Ibid.
[543] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[544] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.
[545] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.

Compressed Air – Refrigerated Air Dryers

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: The installation of cycling or variable frequency drive (VFD)-equipped refrigerated compressed air dryers. Refrigerated air dryers remove the moisture from a compressed air system to enhance overall system performance. An efficient refrigerated dryer cycles on and off or uses a variable speed drive as required by the demand for compressed air instead of running continuously. Only properly sized refrigerated air dryers used in a single-compressor system are eligible.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Compressed Air
Program: C&I New Construction and Major Renovation

Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = (CFM_{DRYER})(SAVE)(Hours)$$
$$\Delta kW = (CFM_{DRYER})(SAVE)$$

Where:
CFM_{DRYER} = Full flow rated capacity of the refrigerated air dryer in cubic feet per minute (CFM). Obtain from equipment's Compressed Air Gas Institute Datasheet.
Save = Refrigerated air dryer kW reduction per dryer full flow rated CFM. See Table 31.
Hours = Annual operating hours of the refrigerated air dryer.

Table 31: Default kW Reduction per CFM by Dryer Capacity (*SAVE*)

Dryer Capacity (CFM_{DRYER})	kW Reduction per CFM (Save)[546]
<100	0.00474
≥100 and <200	0.00359
≥200 and <300	0.00316
≥300 and <400	0.00290
≥400	0.00272

[546] From NSTAR analysis based on metering data. The location of original data and analysis is unknown; however, these values are supported by multiple 3rd party impact evaluations. Single set of savings numbers used since VFD and cycling savings similar down to 40-50% load and prescriptive compressor loading is in the 50-60% range.

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.

Hours

The annual hours of operation for compressed air dryers are site-specific.

Measure Life

The measure life is 15 years.[547]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Refrigerated Air Dryers	NC	National Grid	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Refrigerated Air Dryers	NC	NSTAR, CLC	1.00	1.00	1.25	0.95	0.80	0.88	0.69	n/a	n/a
Refrigerated Air Dryers	NC	Unitil	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Refrigerated Air Dryers	NC	WMECO	1.00	1.00	0.90	0.95	0.80	0.88	0.69	0.77	0.54

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[548]
- NSTAR, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[549]
- WMECO: energy RRs are from 2007/2008 Large C&I Programs impact evaluation[550], demand RRs from impact evaluation of NSTAR 2006 compressed air installations referenced above.

[547] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[548] 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.
[549] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.

Coincidence Factors

- National Grid, Unitil, WMECO: seasonal CFs based on impact evaluation of PY 2004 compressed air installations.[551]
- NSTAR, CLC, WMECO: on-peak CFs based on standard assumptions.

[550] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.

[551] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.

Compressed Air – Low Pressure Drop Filters

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Filters remove solids and aerosols from compressed air systems. Low pressure drop filters have longer lives and lower pressure drops than traditional coalescing filters resulting in higher efficiencies.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity & Retrofit
End Use: Compressed Air
Program: C&I New Construction, C&I Large Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (Quantity)(HP_{COMP})(0.7457)(\%Savings)(Hours)$$
$$\Delta kW = (Quantity)(HP_{COMP})(0.7457)(\%Savings)$$

Where:

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

Baseline Efficiency

The baseline efficiency case is a standard coalescing filter with initial drop of between 1 and 2 pounds per sq inch (psi) with an end of life drop of 10 psi.

High Efficiency

The high efficiency case is a low pressure drop filter with initial drop not exceeding 1 psi over life and 3 psi at element change. Filters must be deep-bed, “mist eliminator” style and installed on a single operating compressor rated 15 – 75 HP.

Hours

The annual hours of operation are site specific and will be determined on a case by case basis.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 5 years. For retrofit projects, the lifetime is 3 years.[552]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
LP Drop Filter	NC, Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
LP Drop Filter	NC, Large Retrofit	NSTAR, CLC	1.00	1.00	1.25	0.95	0.80	0.88	0.69	n/a	n/a
LP Drop Filter	NC, Large Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
LP Drop Filter	NC, Large Retrofit	WMECO	1.00	1.00	0.90	0.95	0.80	0.88	0.69	custom	custom

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[553]
- NSTAR, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[554]
- WMECO: energy RRs from 2011 WMECO C&I impact evaluation.[555], demand RRs from impact evaluation of NSTAR 2006 compressed air installations referenced above.

Coincidence Factors
- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations.556
- NSTAR, CLC, WMECO: on-peak CFs based on standard assumptions.
- WMECO: seasonal CFs are custom calculated

[552] Based on typical replacement schedules for low pressure filters (NSTAR staff estimates).
[553] 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.
[554] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[555] KEMA (2011). 2007/2008 Large C&I Programs. Prepared for Western Massachusetts Electric Company.
[556] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.

Compressed Air – Zero Loss Condensate Drains

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Drains remove water from a compressed air system. Zero loss condensate drains remove water from a compressed air system without venting any air, resulting in less air demand and consequently greater efficiency.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity & Retrofit
End Use: Compressed Air
Program: C&I New Construction, C&I Large Retrofit

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (CFM_{pipe})(CFM_{saved})(SAVE)(Hours)$$
$$\Delta kW = (CFM_{pipe})(CFM_{save})(SAVE)$$

Where:

ΔkWh	=	Energy Savings
ΔkW	=	Demand savings
CFM_{pipe}	=	CFM capacity of piping. Site specific.
CFM_{saved}	=	Average CFM saved per CFM of piping capacity: 0.049
Save	=	Average savings per CFM: 0.24386 kW/CFM[557]
Hours	=	Annual operating hours of the zero loss condensate drain.

Baseline Efficiency

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

High Efficiency

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

Hours

The annual hours of operation are site specific and will be determined on a case by case basis.

[557] Based on NSTAR analysis assuming a typical timed drain settings discharge scenario.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 15 years. For retrofit projects, the lifetime is 13 years.[558]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Zero Loss Drain	NC, Large Retrofit	National Grid	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Zero Loss Drain	NC, Large Retrofit	NSTAR, CLC	1.00	1.00	1.25	0.95	0.80	0.88	0.69	n/a	n/a
Zero Loss Drain	NC, Large Retrofit	Unitil	1.00	1.00	1.00	1.00	1.00	0.80	0.54	0.77	0.54
Zero Loss Drain	NC, Large Retrofit	WMECO	1.00	1.00	0.90	0.95	0.80	0.88	0.69	custom	custom

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid, Unitil: RRs based on impact evaluation of PY 2004 compressed air installations.[559]
- NSTAR, CLC: energy and demand RRs from impact evaluation of NSTAR 2006 compressed air installations[560]
- WMECO: energy RRs from 2011 WMECO C&I impact evaluation.[561], demand RRs from impact evaluation of NSTAR 2006 compressed air installations referenced above.

Coincidence Factors
- National Grid, Unitil: CFs based on impact evaluation of PY 2004 compressed air installations.[562]
- NSTAR, CLC, WMECO: on-peak CFs based on standard assumptions.
- WMECO: seasonal CFs are custom calculated.

[558] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1. Drains not expected to change during life of compressor.
[559] 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.
[560] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Table 17.
[561] KEMA (2011). 2007/2008 Large C&I Programs. Prepared for Western Massachusetts Electric Company.
[562] DMI (2006). *Impact Evaluation of 2004 Compressed Air Prescriptive Rebates*. Prepared for National Grid; results analyzed in RLW Analytics (2006). *Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in the Energy Initiative and Design 2000 Programs*. Prepared for National Grid.

Motors/Drives – Variable Frequency Drives

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.
Primary Energy Impact: Electric
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: Motors/Drives
Program: C&I New Construction & Major Renovation, C&I Large Retrofit, C&I Small Retrofit

Notes

The Large Commercial & Industrial Evaluation Research Area will be commencing an impact evaluation of this measure starting the Fall of 2010. The results of this study will result in either modifications to the savings factors or the realization rates and will be used for reporting on the 2011 program year.

Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (HP)\left(\frac{1}{\eta_{motor}}\right)(kWh/HP)$$

$$\Delta kW = (HP)\left(\frac{1}{\eta_{motor}}\right)(kW/HP)_{SP}$$

Where:

HP	=	Rated horsepower for the impacted motor.
η_{motor}	=	Motor efficiency
kWh/HP	=	Annual electric energy reduction based on building and equipment type. See Table 32.
kW/HP_{SP}	=	Summer demand reduction based on building and equipment type. See Table 32.
kW/HP_{WP}	=	Winter demand reduction based on building and equipment type. See Table 32.

Table 32: Savings Factors for C&I VFDs (kWh/HP and kW/HP)[563]

	Building Exhaust Fan	Cooling Tower Fan	Chilled Water Pump	Boiler Feed Water Pump	Hot Water Circulating. Pump	MAF - Make-up Air Fan	Return Fan	Supply Fan	WS Heat Pump Circulating Loop
Annual Energy Savings Factors (kWh/HP)									
University/College	3,641	449	745	2,316	2,344	3,220	1,067	1,023	3,061
Elm/H School	3,563	365	628	1,933	1,957	3,402	879	840	2,561
Multi-Family	3,202	889	1,374	2,340	2,400	3,082	1,374	1,319	3,713
Hotel/Motel	3,151	809	1,239	2,195	2,239	3,368	1,334	1,290	3,433
Health	3,375	1,705	2,427	2,349	2,406	3,002	1,577	1,487	3,670
Warehouse	3,310	455	816	2,002	2,087	3,229	1,253	1,205	2,818
Restaurant	3,440	993	1,566	1,977	2,047	2,628	1,425	1,363	3,542
Retail	3,092	633	1,049	1,949	2,000	2,392	1,206	1,146	2,998
Grocery	3,126	918	1,632	1,653	1,681	2,230	1,408	1,297	3,285
Offices	3,332	950	1,370	1,866	1,896	3,346	1,135	1,076	3,235
Summer Demand Savings Factors (kW/HP_{SP})									
University/College	0.109	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.056
Elm/H School	0.377	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.275
Multi-Family	0.109	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.056
Hotel/Motel	0.109	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.056
Health	0.109	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.056
Warehouse	0.109	-0.023	0.056	0.457	0.457	0.261	0.102	0.064	0.056
Restaurant	0.261	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.178
Retail	0.109	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.056
Grocery	0.261	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.178
Offices	0.109	-0.023	0.056	0.457	0.457	0.109	0.102	0.064	0.056
Winter Demand Savings Factors (kW/HP_{WP})									
University/College	0.377	-0.006	0.457	0.457	0.457	0.109	0.113	0.113	0.457
Elementary/High School	0.457	-0.006	0.457	0.457	0.457	0.109	0.113	0.113	0.457
Multi-Family	0.109	-0.006	0.457	0.355	0.384	0.109	0.113	0.113	0.355
Hotel/Motel	0.109	-0.006	0.457	0.418	0.444	0.109	0.113	0.113	0.418
Health	0.377	-0.006	0.457	0.275	0.298	0.109	0.113	0.113	0.275
Warehouse	0.377	-0.006	0.457	0.178	0.193	0.261	0.113	0.113	0.178
Restaurant	0.109	-0.006	0.457	0.355	0.384	0.109	0.113	0.113	0.355
Retail	0.109	-0.006	0.457	0.275	0.298	0.109	0.113	0.113	0.275
Grocery	0.457	-0.006	0.457	0.418	0.444	0.109	0.113	0.113	0.418
Offices	0.457	-0.006	0.457	0.418	0.444	0.109	0.113	0.113	0.418

Baseline Efficiency

The baseline efficiency case for this measure varies with the equipment type. All baselines assume either a constant speed motor or 2-speed motor. In the baselines, air or water volume/temperature is controlled using valves, dampers, and/or reheats.

[563] Chan, Tumin (2010). *Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.* Prepared for NSTAR.

High Efficiency

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

Hours

Hours vary by end use and building type.

Measure Life

For lost-opportunity installations, the lifetime for this measure is 15 years. For retrofit projects, the lifetime is 13 years.[564]

Secondary Energy Impacts

There are no secondary energy impacts.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
VFD	NC	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
VFD	Large Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
RRs for all PAs set to 1.0 pending impact evaluation.

Coincidence Factors
CFs for all PAs set to 1.0 based summer and winter factors in gross calculation and pending impact evaluation.

[564] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

Custom Measures (Large C&I)

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: All
Program: C&I New Construction & Major Renovation, C&I Large Retrofit

Notes

In 2011 the PAs agreed on the following set of categories for Large C&I custom projects. All Large C&I Custom projects will be assigned to one of the following categories for future statewide impact evaluation.

Custom Category	Description
Comprehensive Design	New construction projects which address multiple end-uses, reach 20%+ total energy savings, and use whole-building simulations for ex-ante savings estimates and Retrofit projects which address multiple end-uses, reach 15%+ electric energy savings, and do not require whole-building simulations.
Compressed Air	New construction and/or retrofit projects for compressed air systems.
CHP	Combined Heat and Power projects.
HVAC	New construction and/or retrofit projects for HVAC system equipment and controls.
Lighting	New construction and/or retrofit projects for lighting system equipment and controls.
Motor	New construction and/or retrofit projects for motor installations or controls.
Other	New construction and/or retrofit projects that do not fit in with other categories.
Process	New construction and/or retrofit projects for process system equipment and controls.
Refrigeration	New construction and/or retrofit projects for refrigeration system equipment and controls.
Verified Savings	Retrofit "Pay-for-Performance" projects for which savings are estimated based on post-installation measurement and verification.

Algorithms for Calculating Primary Energy Impact

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

Baseline Efficiency

For Lost Opportunity projects, the baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice. For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined based on specific project using the common custom measure life recommendations.[565]

Secondary Energy Impacts

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

Non-Energy Impacts

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

[565] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-2.

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Comprehensive Design	NSTAR, CLC, Unitil, WMECO	1.00	1.00	0.91	0.64	0.60	custom	custom	custom	custom
	National Grid	1.00	1.00	0.97	0.64	0.55	custom	custom	n/a	n/a
Compressed Air	All	1.00	1.00	0.85	0.76	0.74	custom	custom	custom	custom
CHP	NSTAR	1.00	1.00	1.15	1.00	1.00	custom	custom	custom	custom
	National Grid	1.00	1.00	0.86	1.00	1.00	custom	custom	custom	custom
	WMECO	1.00	1.00	1.00	1.00	1.00	custom	custom	custom	custom
HVAC	CLC, Unitil, WMECO	1.00	1.00	1.10	0.94	0.75	custom	custom	custom	custom
	National Grid	1.00	1.00	1.01	0.84	0.82	custom	custom	n/a	n/a
	NSTAR	1.00	1.00	1.24	0.94	0.75	custom	custom	n/a	n/a
Lighting	National Grid	1.00	1.00	0.97	1.16	0.85	custom	custom	n/a	n/a
	NSTAR	1.00	1.00	1.02	0.85	0.84	custom	custom	n/a	n/a
	CLC	1.00	1.00	0.98	0.94	0.92	custom	custom	n/a	n/a
	Unitil	1.00	1.00	0.98	0.94	0.92	custom	custom	n/a	n/a
	WMECO	1.00	1.00	0.98	0.85	0.84	custom	custom	custom	custom
Motor	National Grid	1.00	1.00	0.82	0.80	0.83	custom	custom	n/a	n/a
	NSTAR, CLC	1.00	1.00	0.67	0.85	0.78	custom	custom	n/a	n/a
	Unitil	1.00	1.00	1.00	1.00	1.00	custom	custom	n/a	n/a
	WMECO	1.00	1.00	1.31	0.85	0.78	custom	custom	custom	custom
Process	National Grid	1.00	1.00	0.68	0.96	0.82	custom	custom	n/a	n/a
	NSTAR	1.00	1.00	1.04	0.80	1.11	custom	custom	n/a	n/a
	CLC	1.00	1.00	0.76	0.82	0.88	custom	custom	n/a	n/a
	Unitil	1.00	1.00	0.76	0.82	0.88	custom	custom	n/a	n/a
	WMECO	1.00	1.00	0.76	0.80	1.11	custom	custom	custom	custom
Refrigeration	National Grid	1.00	1.00	0.82	0.80	0.83	custom	custom	n/a	n/a
	NSTAR, CLC	1.00	1.00	0.85	0.41	0.24	custom	custom	n/a	n/a
	Unitil	1.00	1.00	1.00	1.00	1.00	custom	custom	n/a	n/a
	WMECO	1.00	1.00	0.90	0.41	0.24	custom	custom	custom	custom
Verified Savings[566]	Statewide	1.00	1.00	1.00	1.00	1.00	custom	custom	custom	custom

Note: Unless otherwise stated, PA's use Statewide results.

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

[566] The PAs assume 100% realization rates for verified savings projects because gross savings assumptions are based on post-installation verification and analysis. This custom category is new in 2011 and has not been evaluated.

Realization Rates

- Comprehensive: Realization rates from statewide impact evaluation completed in 2011. National Grid uses PA specific values, all other PA's use statewide values due to small sample size.[567]
- HVAC: Realization rates from statewide impact evaluation completed in 2011. National Grid and NSTAR use PA specific values, all other PA's use statewide values due to small sample size.[568]
- CHP: NSTAR and National Grid CHP RRs from National Grid / NSTAR impact evaluation of CHP 2010 projects.[569]
- Compressed Air: Realization rates from statewide impact evaluation completed in 2012.[570] All PA's use statewide values due to poor precision on a PA level.
- Lighting: Realization rates from statewide impact evaluation completed in 2012.[571] National Grid and NSTAR use PA specific values, all other PA's use statewide values due to small sample size.
- Process: Realization rates from statewide impact evaluation completed in 2012.[572] National Grid and NSTAR use PA specific values, all other PA's use statewide values due to small sample size.
- Motor, Other, and Refrigeration realization rates based on previous PA-specific impact evaluations. No statewide evaluations have been performed for these categories:
    - National Grid rates from impact evaluation analysis of the National Grid 2009 custom program.[573] Motor, Other and Refrigeration projects are included in the Process populations.
    - NSTAR, CLC rates for non-lighting from NSTAR impact evaluation of large C&I 2006 programs.[574]
    - Unitil RRs have not been evaluated for this program so 100% is used.
    - WMECO energy RRs are from 2007/2008 Large C&I Programs impact evaluation[575]
- For WMECO kW RRs, all values are based on NSTAR references above.

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.

[567] KEMA, Inc. and SBW (2011). Impact Evaluation of 2008 and 2009 Custom CDA Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[568] KEMA, Inc. and DMI (2011). Impact Evaluation of 2009 Custom HVAC Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[569] KEMA (2012). *2010 Combined Heat and Power Impact Evaluation Methodology and Analysis Memo.* Prepared for National Grid and NSTAR; Table 1-1
[570] KEMA (2012). Impact Evaluation of 2010 Custom Process and Compressed Air Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[571] KEMA (2012). Impact Evaluation of the 2010 Custom Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
[572] Ibid.
[573] KEMA, Inc. (2010). *Sample Design and Impact Evaluation Analysis of the 2009 Custom Program.* Prepared for National Grid; Table 17.
[574] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Tables 14-18.
[575] KEMA, Inc. (2010). *2007/2008 Large C&I Programs, Phase 1 Report Memo for Lighting and Process Measures*. Prepared for Western Massachusetts Electric Company.

Custom Measures (Small C&I)

Version Date and Revision History

Effective Date: 1/1/2011 (Revised 1/1/2012)
End Date: TBD

Measure Overview

Description: The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.
Primary Energy Impact: Electric
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Retrofit
End Use: All
Program: C&I Small Retrofit

Algorithms for Calculating Primary Energy Impact

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

Baseline Efficiency

For Lost Opportunity projects, the baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice. For retrofit projects, the baseline efficiency case is the same as the existing, or pre-retrofit, case for the facility.

High Efficiency

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined based on specific project using the common custom measure life recommendations.[576]

Secondary Energy Impacts

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

Non-Energy Impacts

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

Impact Factors for Calculating Adjusted Gross Savings

Measure	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}	CF_{SSP}	CF_{WSP}
Lighting	National Grid	1.00	1.00	1.03	1.04	1.12	custom	custom	n/a	n/a
Refrigeration	National Grid	1.00	1.00	1.60	1.49	0.69	custom	custom	n/a	n/a
Other	National Grid	1.00	1.00	0.81	0.77	0.53	custom	custom	n/a	n/a
Lighting Systems	NSTAR	1.00	1.00	1.02	0.99	0.99	custom	custom	n/a	n/a
Lighting Controls	NSTAR	1.00	1.00	0.42	0.92	0.92	custom	custom	n/a	n/a
VSD	NSTAR	1.00	1.00	0.67	0.85	0.78	custom	custom	n/a	n/a
Other Non-Lighting Systems	NSTAR, CLC	1.00	1.00	0.91	0.92	0.92	custom	custom	n/a	n/a
Street Lighting	CLC	1.00	1.00	1.00	1.00	1.00	custom	custom	n/a	n/a
Lighting Controls	CLC	1.00	1.00	0.42	0.92	0.92	custom	custom	n/a	n/a
Lighting	Unitil	1.00	1.00	1.08	0.99	0.99	custom	custom	n/a	n/a
Non-Lighting	Unitil	1.00	1.00	1.08	1.00	1.00	custom	custom	n/a	n/a
Lighting Systems	WMECO	1.00	1.00	1.02	0.99	0.99	custom	custom	0.67	0.58
Lighting Controls	WMECO	1.00	1.00	0.42	0.92	0.92	custom	custom	0.67	0.58
Other	WMECO	1.00	1.00	1.00	0.92	0.92	custom	custom	custom	custom
Other (Hot Water, Process, Motors)	WMECO	1.00	1.00	1.00	0.92 / 0.85	0.92 / 0.78	custom	custom	custom	custom

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
- National Grid RRs derived from impact evaluation of 2005 SBS program[577]
- NSTAR VSD rates from impact evaluation of C&I 2006 programs[578]

[576] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-2.
[577] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation*. Prepared for National Grid; Table 4.
[578] RLW Analytics (2008). *Business & Construction Solutions (BS/CS) Programs Measurement & Verification - 2006 Final Report*. Prepared for NSTAR Electric and Gas; Tables 14-18

- NSTAR, WMECo, and CLC RRs from the 2011 Small C&I Non-Controlled Lighting impact evaluation [579]; other non-lighting energy and all demand RRs based on NSTAR 2002–2004 small retrofit impact evaluations, Lighting Controls from Small Business Direct Install Program: Pre/Post Lighting Controls Study June 2012
- Unitil RRs from Small Business program impact evaluation.[580]

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.

[579] Cadmus Group (2011). *Non-Controls Lighting Evaluation for the Massachusetts Small Commercial Direct Install Program*. Prepared for Massachusetts Utilities.

[580] Summit Blue Consulting, LLC (2008). *Multiple Small Business Services Programs Impact Evaluation 2007 – Final Report Update*. Prepared for Cape Light Compact, National Grid, NSTAR, Unitil and Western Massachusetts Electric Company.

Residential Natural Gas Efficiency Measures

Behavior – OPOWER Gas

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: The Behavior/Feedback programs send monthly energy use reports to participating gas customers in order to change customers' energy-use behavior.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Products and Services
End Use: Behavior
Program: Behavior/Feedback Program

Algorithms for Calculating Primary Energy Impact

Unit saving are deemed based on study results:

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

Where:
Unit = One participant household
ΔMMBtu = Average annual gas heating MMBtu savings per unit. See Table 33.
$MMBtu_{BASE}$ = Average baseline consumption MMBtu per unit. See Table 33.
%SAVE = Annual percent of MMBtu savings per unit. See Table 33.

Table 33: Savings Factors for Behavior/Feedback Program[581]

Measure	PA	2013			2014			2015		
		MMBtu BASE	%Save	ΔMMBtu	MMBtu BASE	%Save	ΔMMBtu	MMBtu BASE	%Save	ΔMMBtu
Group 2009	National Grid	127.20	1.64	2.08	127.20	1.65	2.10	127.20	1.64	2.08
Group 2010	National Grid	31.28	1.21	0.38	130.50	1.35	1.76	130.50	1.34	1.75
Group 2011	National Grid	92.90	1.30	1.21	92.90	1.31	1.21	92.90	1.30	1.21
Group 2011 Add	National Grid	19.44	0.76	0.15	81.10	1.35	1.09	81.10	1.34	1.09
Group 2012	National Grid	81.00	1.34	1.09	81.00	1.35	1.09	81.00	1.34	1.09

[581] ODC/Navigant (2011) *Massachusetts Cross-cutting Behavioral Program Evaluation,* updated with vendor projections for 2013-2015.

Group 2012 Dual	National Grid	84.20	0.7%	0.64	84.20	0.76	0.64	84.20	0.75	0.64
Group 2013	National Grid	76.18	0.85	0.81	76.18	1.23	1.17	76.18	1.22	1.17
Group 2014	National Grid	n/a	n/a	n/a	55.00	0.95	0.52	55.00	1.18	0.65
Group 2015	National Grid	n/a	n/a	n/a	n/a	n/a	n/a	55.00	0.94	0.52
Gas Group 2010	NSTAR	102.2	1.68	1.72	102.2	1.72	1.76	102.2	1.75	1.79
Gas Group 2011	NSTAR	89.6	1.59	1.42	89.6	1.70	1.52	89.6	1.72	1.54
Attrition Refill 2013	NSTAR	65.5	1.11	0.73	103.6	1.68	1.74	103.6	1.67	1.73
Attrition Refill 2014	NSTAR	n/a	n/a	n/a	2.68	1.02	0.27	89.6	1.55	1.39

Baseline Efficiency

The baseline efficiency case is a customer who does not receive Behavior/Feedback program reports.

High Efficiency

The high efficiency case is a customer who does receive Behavior/Feedback program reports.

Hours

Not applicable.

Measure Life

The measure life is 1 year[582].

Secondary Energy Impacts

There are no secondary energy impacts for this measure

Non-Energy Impacts

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

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
OPOWER Group	Behavior/Feedback	National Grid	1.00	1.00	1.00	n/a	n/a	n/a	n/a
OPOWER Group	Behavior/Feedback	NSTAR	1.00	1.00	1.00	n/a	n/a	n/a	n/a

[582] Vendor estimate.

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
RRs are 100% because deemed savings are based on assumptions from year-to-date vendor findings. 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.

Hot Water – Water Heaters

Version Date and Revision History

Effective Date: 1/1/2011 (Revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of high efficiency gas water heaters: *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. *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. *Stand-alone storage water heaters* are high efficiency water heaters that are not combined with space heating devices. *Tankless water heaters* circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank.
Primary Energy Impact: Natural Gas (Residential DHW)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: Hot Water
Program: Residential Heating and Water Heating

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
ΔMMBtu = Annual MMBtu savings per unit. See Table 34.

Table 34: Savings for Residential Water Heaters

Equipment Type	Efficiency Requirement	2013 ΔMMBtu	2014 ΔMMBtu	2015 ΔMMBtu
Condensing Water Heater	TE >=95	8.5[583]	8.5	7.7[584]
Indirect Water Heater	ENERGY STAR® Boiler	8.0[585]	8.0	8.0
Stand-Alone Storage Water Heater	EF >= 0.67	3.7[586]	3.7	1.9[587]
On-Demand Tankless Water Heater	EF >= 0.82	9.7[588]	9.7	5.5[589]
	EF >= 0.94	10.3[590]	10.3	7.6[591]

Baseline Efficiency

In 2013 and 2014, the baseline efficiency case is a stand alone tank water heater with an energy factor of 0.575. In 2015, the baseline efficiency case is a stand alone tank water heater with an energy factor of 0.61.

High Efficiency

The high efficiency case is a stand-alone storage water heater with an energy factor >= 0.67, a condensing water heater with a TE>= 0.95, a tankless water heater with an energy factor >= 0.82, or an indirect water heater attached to an ENERGY STAR® rated forced hot water gas boiler.

Hours

Not applicable.

Measure Life

The measure lives vary by water heater type and are described in the table below.

[583] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE Gas Space and Water Heating Measures*; June 8, 2012.
[584] Ibid.
[585] Nexus Market Research and The Cadmus Group (2010). *HEHE Process and Impact Evaluation*. Prepared for GasNetworks.
[586] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[587] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE Gas Space and Water Heating Measures*; June 8, 2012.
[588] Nexus Market Research and The Cadmus Group (2010). *HEHE Process and Impact Evaluation*. Prepared for GasNetworks.
[589] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE.Gas Space and Water Heating Measures*; June 8, 2012
[590] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10, energy consumption estimated using the DOE test procedure. Based on the following formula: (41,045 BTU/EF x 365)/1,000,000.
[591] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE.Gas Space and Water Heating Measures*; June 8, 2012

Table 35: Measure Lives for Residential Water Heaters

Measure	Measure Life (years)
Condensing Water Heater	15[592]
Indirect Water Heater	20[593]
Stand-Alone Storage Water Heater	13[594]
On-Demand Tankless Water Heater	20[595]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Water Heater	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Indirect Water Heater	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Stand Alone Storage Water Heater	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
On-Demand Tankless Water Heater	Residential HEHE	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[592] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[593] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[594] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[595] Ibid.

Hot Water – Showerheads

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: An existing showerhead with a high flow rate is replaced with a new low flow showerhead.
Primary Energy Impact: Natural Gas (Residential DHW)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential
Market: Retrofit
End Use: Hot Water
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Number of showerheads.
ΔMMBtu = Annual MMBtu savings per unit. 1.2 MMBtu[596]

Baseline Efficiency

The baseline efficiency case is the existing showerhead with a high flow.

High Efficiency

The high efficiency case is a low flow showerhead.

Hours

Not applicable.

Measure Life

The measure life is 7 years[597]

[596] The Cadmus Group (2012). *Home Energy Services Impact Evaluation.* Prepared for Massachusetts Program Administrators.
[597] Massachusetts common assumption

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Gallons water saved per year per unit that received DHW measures[598]	3,696 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Showerhead	HES	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[598] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators

Hot Water – Faucet Aerator

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: An existing faucet aerator with a high flow rate is replaced with a new low flow showerhead.
Primary Energy Impact: Natural Gas (Residential DHW)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts, Residential Water
Sector: Residential
Market: Retrofit
End Use: Hot Water
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Number of faucet aerators.
ΔMMBtu = Annual MMBtu savings per unit. 0.2 MMBtu[599]

Baseline Efficiency

The baseline efficiency case is the existing faucet aerator with a high flow.

High Efficiency

The high efficiency case is a low flow faucet aerator.

Hours

Not applicable.

Measure Life

The measure life is 7 years[600]

[599] The Cadmus Group (2012). *Home Energy Services Impact Evaluation.* Prepared for Massachusetts Program Administrators.
[600] Massachusetts common assumption

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Residential Water	Gallons water saved per year per unit that received DHW measures[601]	332 Gallons/Participant
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Faucet Aerator	HES	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[601] NMR Group, Inc., Tetra Tech (2011). *Massachusetts Special and Cross-Sector Studies Area, Residential and Low-Income Non-Energy Impacts (NEI) Evaluation,* Prepared for Massachusetts Program Administrators

HVAC – Boilers

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of a new high efficiency gas-fired boiler for space heating.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Heating and Water Heating

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installation of high efficiency boiler
ΔMMBtu = Annual MMBtu savings per unit. See Table 36 for values.

Table 36: Savings for Residential Boilers

Measure	ΔMMBtu
Boiler (AFUE >= 90%)	10.4[602]
Boiler (AFUE >= 96%)	13.1[603]

Baseline Efficiency

The baseline efficiency case is an 82% AFUE boiler.

High Efficiency

The high efficiency case is a boiler with an AFUE of 90% or greater. For savings calculations a 93% AFUE and a 96% AFUE boiler is used for the high efficiency cases.

Hours

Not applicable.

[602] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE.Gas Space and Water Heating Measures*; June 8, 2012
[603] Ibid.

Measure Life

The measure life is 20 years.[604]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler (AFUE >=90%)	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Boiler (AFUE >=96%)	Residential HEHE	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[604] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers.*

HVAC – Boiler Reset Controls

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Residential Heating and Water Heating, Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed boiler reset control
ΔMMBtu = Annual MMBtu savings per unit: 4.5 MMBtu[605]

Baseline Efficiency

The baseline efficiency case is a boiler without reset controls.

High Efficiency

The high efficiency case is a boiler with reset controls.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[606]

[605] The Cadmus Group (2012). *Home Energy Services Impact Evaluation.* Prepared for Massachusetts Program Administrators.
[606] ACEEE (2006). Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler Reset Controls	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Boiler Reset Controls	HES	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

HVAC – Combo Water Heater/Boiler

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: Residential Heat
Program: Residential Heating and Water Heating

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Installation of integrated water heater/boiler unit
ΔMMBtu = Annual MMBtu savings per unit: See Table 37.

Table 37: Savings for Residential Combo Water Heater/Boilers

Measure	2013 ΔMMBtu	2014 ΔMMBtu	2015 ΔMMBtu
Combo Water Heater/Condensing Boiler (90% AFUE, 0.90 EF)	17.8[607]	17.8[608]	17.5[609]

Baseline Efficiency

In 2013 and 2104 the baseline efficiency case is an 82% AFUE boiler with a 0.594 EF water heater. In 2015 the baseline efficiency case is an 82% AFUE boiler with a 0.61 EF water heater.

High Efficiency

The high efficiency case is an integrated water heater/boiler unit with a 90% AFUE condensing boiler and a 0.9 EF water heater.

[607] Based on information provided in GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks.
[608] Ibid.
[609] Ibid.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[610]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Combo Water Heater/Condensing Boiler	Residential HEHE	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[610] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*; measure life assumed to be the same as a boiler.

HVAC – Early Replacement Boiler

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Early retirement of inefficient gas-fired boiler and installation of new high efficiency gas-fired boiler.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Home Energy Services

Algorithms for Calculating Primary Energy Impact

Unit savings for the early replacement of an existing boiler with a high efficiency boiler are counted in two parts: (1) early retirement savings for a code-compliant boiler compared to the existing boiler over the remaining lifetime of the existing boiler, and (2) efficiency savings for the high efficiency boiler compared to a code-compliant boiler for the full life of the new high efficiency boiler:

$$\Delta MMBtu = \Delta MMBtu_{RETIRE} + \Delta MMBtu_{EE}$$

Where:

Unit	=	Removal of existing inefficient boiler and installation of new high efficiency boiler
$\Delta MMBtu_{RETIRE}$	=	Annual MMBtu savings of code-compliant boiler compared to existing boiler: 23.6 MMBtu for forced hot water [611] and 43.9 MMBTU for steam[612]
$\Delta MMBtu_{EE}$	=	Annual MMBtu savings of high efficiency boiler compared to code-compliant boiler: 10.4 MMBtu for forced hot water[613] and 3.5 MMBtu for steam[614]

Baseline Efficiency

For the retirement savings over the remaining life of existing boiler, the baseline is the existing inefficient boiler estimated to be 65% AFUE for a forced hot water boiler and 55% for a steam boiler. For the high

[611] Calculated using information provided in The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE Gas Space and Water Heating Measures*; June 8, 2012
[612] Calculated using information from GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks
[613] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE Gas Space and Water Heating Measures*; June 8, 2012
[614] Calculated using information from GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks

efficiency unit savings over lifetime of the new boiler, the baseline is a code-compliant boiler (AFUE = 82% for forced hot water and 80% for steam boiler).

High Efficiency

For the retirement savings over the remaining life of existing boiler, the efficient case is a code-compliant boiler (AFUE = 82% for forced hot water and 80% for steam). For the high efficiency savings over lifetime of the new boiler, the efficient case is a new high efficiency (AFUE >= 93% for forced hot water and 82% for steam).

Hours

Not applicable.

Measure Life

The remaining life for the existing unit is 10 years[615], and the measure life of new equipment is 20 years.[616]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Early Replacement Boiler (Retire)	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Early Replacement Boiler (EE)	Residential HEHE	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

[615] Agreed upon with EEAC consultants as a reasonable approximation for the number of years an existing boiler would continue to operate if it had not been replaced early due to the program.
[616] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers.*

Coincidence Factors

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

HVAC – Furnaces

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of a new high efficiency space heating gas-fired furnace with an electronically commutated motor (ECM) for the fan.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Heating and Water Heating

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Installation of furnace with ECM
ΔMMBtu = Annual MMBtu savings per unit. See Table 38.

Table 38: Savings for Residential Furnaces

Equipment Type	Efficiency	ΔMMBtu
Furnace (Forced Hot Air) w/ECM	AFUE = 95%	4.5[617]
	AFUE = 97%	5.9[618]

Baseline Efficiency

The baseline efficiency case is a 90% AFUE furnace.

High Efficiency

The high efficiency case is a new furnace with AFUE >= 95% with an electronically commutated motor installed.

[617] The Cadmus Group, Inc. (2012) *Memo to HEHE Program Administrators Re: Impacts of Upcoming Federal Standards on HEHE.Gas Space and Water Heating Measures*; June 8, 2012
[618] Ibid.

Hours

Not applicable.

Measure Life

The measure life is 18 years.[619]

Secondary Energy Impacts

High efficiency furnaces equipped with ECM fan motors also save electricity from reduced fan energy requirements. See HVAC - Furnace Fan Motors in the Residential Electric section.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Furnace w/ECM	Residential HEHE	All	1.00	1.00	1.00	1.00	1.00	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[619] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*.

HVAC – Heat Recovery Ventilator

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 2012)
End Date: TBD

Measure Overview

Description: Heat Recovery Ventilators (HRV) can help make mechanical ventilation more cost effective by reclaiming energy from exhaust airflows.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: None
Sector: Residential
Market: Lost Opportunity
End Use: HVAC
Program: Residential Heating and Water Heating

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMbtu = \Delta MMbtu$$

Where:
Units = Number of heat recovery ventilation systems installed
ΔMMBtu = Annual MMBtu savings per unit: 7.7 MMBtu [620]

Baseline Efficiency

The baseline efficiency case is an ASHRAE 62.2-compliant exhaust fan system with no heat recovery.

High Efficiency

The high efficiency case is an exhaust fan system with heat recovery.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[621]

[620] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[621] Ibid.

Secondary Energy Impacts

An electric penalty results due to the electricity consumed by the system fans.

Measure	Energy Type	ΔkWh/Unit[622]	ΔkW/Unit[623]
Heat Recovery Ventilator	Electric	-133	-0.04

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heat Recovery Ventilator	Residential HEHE	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 programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model .[624]

[622] Ibid
[623] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[624] Ibid.

HVAC – Heating System Replacement

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Replacement of an existing gas heating system with a new high efficiency system. Electric savings are achieved from reduced fan run time.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low-Income
Market: Retrofit
End Use: HVAC
Program: Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installation of new high efficiency gas heating system.
ΔMMBtu = Annual average MMBtu savings per unit: 19.9[625] (Furnace 20.7, Boiler 19.4)

Baseline Efficiency

The baseline efficiency case is the existing inefficient heating equipment.

High Efficiency

The high efficiency case is the new efficient heating equipment.

Hours

Not applicable.

Measure Life

The measure life is 18 years[626] for new furnaces and 20 years[627] for new boilers.

[625] The Cadmus Group (2012). *Massachusetts Low Income Single Family Program Impact Evaluation.* Prepared for The Electric and Gas Program Administrators of Massachusetts.
[626] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace.*

Secondary Energy Impacts

Electric savings are from reduced furnace fan runtime. The kWh savings values are deemed based on study results.

.PA	ΔkWh	ΔkW
All	172[628]	0.05[629]

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Heating System Replacement (Gas)	LI SF Retrofit	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 programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% because savings estimates are based on evaluation and analysis results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model [630]

[627] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers.*
[628] The Cadmus Group (2012). *Massachusetts Low Income Single Family Program Impact Evaluation*. Prepared for The Electric and Gas Program Administrators of Massachusetts.
[629] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators.
[630] Ibid.

HVAC – Thermostats

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Installation of a programmable thermostat, which gives the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Residential Heating and Water Heating, Home Energy Services, Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Number of Programmable T-stats installed
ΔMMBtu = Annual MMBtu savings per unit: See Table 39

Table 39: Savings for Thermostats

Program	ΔMMBtu
Residential HEHE	3.2[631]
HES	3.2[632]
MF Retrofit and LI MF Retrofit	2.4[633]

Baseline Efficiency

The baseline efficiency case is an HVAC system using natural gas to provide space heating without a programmable thermostat.

[631] The Cadmus Group (2012). *Home Energy Services Impact Evaluation.* Prepared for Massachusetts Program Administrators.
[632] Ibid.
[633] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.

High Efficiency

The high efficiency case is an HVAC system that has a programmable thermostat installed.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[634]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Programmable Thermostats	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostats	HES	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Programmable Thermostats	MF Retrofit	All	1.00	0.69	1.00	n/a	n/a	n/a	n/a
Programmable Thermostats	LI MF Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor expect for MF Retrofit where Savings Persistence Factors are from the 2011 Residential Retrofit Multifamily Impact Analysis[635].

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.

[634] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*.
[635] The Cadmus Group, Inc. (2012). *Massachusetts 2011Residential Retrofit Multifamily Program Analysis*. Prepared for the Massachusetts Program Administrators

HVAC – Wi-Fi Thermostats

Version Date and Revision History

Draft Date: 9/14/2011
Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: A communicating thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Residential Heating and Water Heating

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Number of Wi-Fi T-stats installed
ΔMMBtu = Annual MMBtu savings per unit: 6.6 MMBtu[636]

Baseline Efficiency

The baseline efficiency case is an HVAC system using natural gas to provide space heating with either a manual or a programmable thermostat.

High Efficiency

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

Hours

Not applicable.

[636] Cadmus Group (2011). Memo: Wi-fi Programmable Thermostat Billing Analysis. Prepared for Keith Miller and Whitney Domigan, National Grid

Measure Life

The measure life is 15 years.[637]

Secondary Energy Impacts

When the thermostat also controls the cooling system the electric savings are 104 kWh[638] and 0.231 kW[639].

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Wi-Fi Thermostats (heating only)	Residential HEHE	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Wi-Fi Thermostats (heating and cooling)	Residential HEHE	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
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.[640]

[637] Assumed to have the same lifetime as a regular programmable thermostat. Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*.
[638] Electric savings based on staff analysis with savings assumptions from Cadmus.
[639] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators
[640] Ibid

HVAC – Weatherization

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of weatherization measures such as air sealing and insulation in gas heated homes. Electric savings are achieved from reduced fan run time.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income Single Family Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Household with weatherization measures installed
ΔMMBtu = Average annual MMBtu savings: 26.3

Baseline Efficiency

The baseline efficiency case is the existing home shell.

High Efficiency

The high efficiency case can be a combination of increased insulation, air sealing, duct sealing, and other improvements to the home shell.

Hours

Not applicable.

Measure Life

The measure lives for weatherization projects may differ depending on the measures implemented. The final measure life of each application is weighted based on the mix of weatherization measures installed. The measure life for each type of weatherization measure is based on statewide measure lives for

residential energy efficiency measures[641]. If installation details are not tracked, the measure life is assumed to be 20 years[642].

Secondary Energy Impact

Electric savings are from reduced furnace fan runtime (206 kWh) and reduced cooling due to weatherization (138 kWh). The kWh savings values are deemed based on study results.

ΔkWh	ΔkW
344[643]	0.31[644]

Non-Energy Benefits

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Weatherization (Gas)	LI SF Retrofit	All	1.00	1.00	1.00	1.00	1.00	1.00	0.36

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are set to 100% because savings estimates are based on evaluation and analysis results.

Coincidence Factors
Summer and winter coincidence factors are estimated using demand allocation methodology described the Cadmus Demand Impact Model [645]

[641] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[642] Ibid.
[643] The Cadmus Group (2012). *Massachusetts Low Income Single Family Program Impact Evaluation*. Prepared for The Electric and Gas Program Administrators of Massachusetts.
[644] Estimated using demand allocation methodology described in: Cadmus Demand Impact Model (2012). Prepared for Massachusetts Program Administrators
[645] Ibid.

Low Income Multifamily – Vendor Calculated Savings (NSTAR)

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Retrofit measures installed through the Low Income Multifamily program including: weatherization and insulation.
Primary Energy Impact: Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: Low-Income Multifamily Retrofit (NSTAR)

Algorithms for Calculating Primary Energy Impact

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

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms, (see attached for details). Infiltration savings use site-specific seasonal factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 and BPI recommendations as their basis. 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.

Multifamily – Air Sealing

Version Date and Revision History

Effective Date: 01/01/2013
End Date: TBD

Measure Overview

Description: Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Program: Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = \frac{Vol \times \Delta ACH \times 0.018 \times HDD \times \frac{24}{\eta_{heating}}}{1{,}000{,}000}$$

Where[646]:

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 of a baseline/pre-retrofit ACH =0.5, and a 20% reduction in infiltration is assumed, which yields a Δ ACH value of 0.10.
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

[646] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.

HDD Values by Weather Station[647]

TMY3 City	HDD	CDH
Barnstable Muni Boa	4379	1349
Beverly Muni	5329	3432
Boston Logan Int'l Arpt	4550	4329
Chicopee Falls Westo	5016	4116
Lawrence Muni	4640	3978
Marthas Vineyard	4312	1345
Nantucket Memorial AP	3988	362
New Bedford Rgnl	4434	4232
North Adams	5234	2524
Norwood Memorial	4872	4763
Otis ANGBb	4718	2588
Plymouth Municipal	4559	2138
Provincetown (AWOS)	4368	2195
Westfield Barnes Muni AP	5301	3784
Worchester Regional Arpt	5816	1753

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 (ACH_{PRE}) for multi-family facilities, which is measured prior to the implementation of the air sealing measure. This will typically be a default value of a baseline/pre-retrofit ACH =0.5

High Efficiency

The baseline efficiency case is the existing building after the air sealing measure is implemented. The high efficiency building is characterized by the new air changes per hour (ACH_{POST}) for multi-family facilities, which is measured after the air sealing measure is implemented. This will typically be a default value of a baseline/pre-retrofit ACH =0.4

Hours

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

Measure Life

The measure life is 15 years.[648]

[647] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.
[648] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Air Sealing	MF Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Air Sealing	LI MF Retrofit	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rates are 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

Multifamily – DHW System

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of high efficiency water heating equipment to replace the existing inefficient water heater.
Primary Energy Impact: Natural Gas (Residential DHW)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: DHW
Program: *National Grid only:* Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = Units \times \frac{18\ MMBtu}{Unit} \times \left(\frac{1}{EF_{BASE}} - \frac{1}{EF_{EE}} \right)$$

Where:

Unit	=	Total number of apartment units utilizing the water heater
18 MMBtu/Unit	=	Average annual water heating energy demand per apartment unit[649]
EF_{BASE}	=	Energy Factor for the baseline water heater
EF_{EE}	=	Energy Factor for the new efficient water heater

Baseline Efficiency

In 2013 and 2014, the baseline efficiency case is a stand alone tank water heater with an energy factor of 0.575. In 2015, the baseline efficiency case is a stand alone tank water heater with an energy factor of 0.61.

High Efficiency

The high efficiency case includes the new efficient water heater with an Energy Factor > 0.575.

Hours

Not applicable.

[649] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.

Measure Life

Measure	Measure Life (years)
Indirect Water Heater	20 [650]
Stand-Alone Storage Water Heater	13 [651]
On-Demand Tankless Water Heater	20 [652]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
MF DHW System	LI MF Retrofit	National Grid	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rate is 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

[650] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[651] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[652] Ibid.

Multifamily – DHW Measures

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: DHW measures include equipment installed to reduce consumption of hot water, insulation installed to reduce losses, or other retrofits which save on hot water heating energy.
Primary Energy Impact: Natural Gas (Residential DHW)
Secondary Energy Impact: None
Non-Energy Impact: Residential Water, Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: Hot Water
Program: Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on program vendor assumptions:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Units = Total quantity of installed units. Units are defined in Table 40.
ΔMMBtu/Unit = Annual MMBtu savings per unit. See Table 40.

Table 40: Savings for MF DHW Measures

Measure	Unit	ΔMMBtu
Faucet Aerator	Each	0.36[653]
Low-Flow Showerhead	Each	0.48[654]
DHW pipe sleeve or pipewrap	Each	0.48[655]
Water Heater Tank Wrap (Small < 50 gallons)	Each	2.187[656]
Water Heater Tank Wrap (Large >= 50 gallons)	Each	2.137[657]
DHW TurnDown to 125°F	Each	0.398[658]

Baseline Efficiency

The baseline is the existing multi-family facility without the efficiency measure(s) installed.

[653] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.
[654] Ibid.
[655] Ibid.
[656] Savings assumptions from National Grid program vendor.
[657] Ibid.
[658] Ibid.

High Efficiency

The high efficiency case is the existing multi-family facility with new efficiency measure(s) installed.

Hours

Not applicable.

Measure Life

The measure life for all DHW measures is 7 years.[659]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Resource	Residential water savings for low-flow showerheads [660]	3,696 gallons/unit
Annual Resource	Residential water savings for faucet aerators [661]	332 gallons/unit
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Faucet Aerator	MF Retrofit	All	1.00	0.96	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead	MF Retrofit	All	1.00	0.93	1.00	n/a	n/a	n/a	n/a
DHW pipe sleeve or pipewrap	MF Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Water Heater Tank Wrap	MF Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
DHW TurnDown to 125°F	MF Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Faucet Aerator	MF LI Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Low-Flow Showerhead	MF LI Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
DHW pipe sleeve or pipewrap	MF LI Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Water Heater Tank Wrap	MF LI Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
DHW TurnDown to 125°F	MF LI Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a

In-Service Rates

[659] Massachusetts Common Assumption.
[660] NMR Group and Tetra Tech (2011). *Residential and Low-Income Non-Energy Impacts (NEI) Evaluation* Prepared for MA Program Administrators
[661] Ibid

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

Savings Persistence Factor

All PAs use 100% savings persistence factor except for evaluated measures in the MF Retrofit program[662].

Realization Rates

The energy realization rates are 100% based on no evaluations.

Coincidence Factors

There are no electric savings for this measure.

[662] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.

Multifamily – Duct Systems

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Ducts are sealed by reconnecting disconnected duct joints and sealing gaps or seams with mastic and fiber-mesh tape as appropriate
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Program: *National Grid only:* Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = AnnualHeatingConsumption \times \%SAVE \times \frac{1}{1{,}000{,}000}$$

Where:
AnnualHeatingConsumption = The total annual heating consumption for the facility (Btu)
%SAVE = Average reduction in energy consumption. See Table 41.
1/1,000,000 = Conversion from Btu to MMBtu

Table 41: Savings Factors for MF Duct Systems

Measure Type	%SAVE[663]
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.

[663] Savings assumptions from National Grid program vendor.

Hours

Not applicable.

Measure Life

The measure life is 20 years.[664]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Duct Sealing	MF Retrofit	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Duct Sealing	LI MF Retrofit	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rate is 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

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

Multifamily – Heating System

Version Date and Revision History

Draft Date: 06/30/2011
Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of high efficiency heating equipment to replace the existing inefficient gas-fired furnace, hydronic boiler, steam boiler or condensing boiler.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Low Income
Market: Retrofit
End Use: HVAC
Program: *National Grid only:* Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = \frac{Btu}{hr} \times \left(\frac{1}{AFUE_{BASE}} - \frac{1}{AFUE_{EE}} \right) \times EFLH_{Heat} \times \frac{1}{1{,}000{,}000}$$

Where:

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

Baseline Efficiency

The baseline efficiency is determined based on the type of heating equipment installed and the table of baseline efficiencies ($AFUE_{BASE}$) below.

Table 42: Baseline Efficiencies for MF Heat System Equipment

Equipment Type	$AFUE_{BASE}$ [665]
Boiler	75%
Furnace	78%

High Efficiency

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

[665] Federal Register / Vol. 73, No. 145 / Monday, July 28, 2008 / Rules and Regulations Pg. 43613

Hours

The equivalent full load hours are assumed to be 1,418 for all multi-family residential facilities in Massachusetts (see Appendix A Table 21 in 2011 Plan TRM).

Measure Life

Equipment Type	Lifetime (years)
Boiler	20 [666]
Furnace	18 [667]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
MF Heat System	LI MF Retrofit	National Grid	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rate is 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

[666] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers.*
[667] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace.*

Multifamily – Pipe Insulation

Version Date and Revision History

Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Insulation upgrades to existing heating system pipes.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low Income
Market: Retrofit
End Use: HVAC
Program: National Grid only: Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

$$\Delta MMBtu = LF \times MMBtu / LF$$

Where:
LF = Linear feet of installed pipe insulation
MMBtu/LF = Deemed MMBtu savings per linear foot of installed insulation

Table 43: Savings for MF Pipe Insulation

Measure	Unit	MMBtu/LF[668]
Heating System Pipe Insulation	Linear Feet	0.160

Baseline Efficiency

The baseline efficiency case is the existing facility or equipment prior to the implementation of additional insulation.

High Efficiency

The baseline efficiency case is the existing facility or equipment after the implementation of additional insulation.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[669]

[668] Savings assumptions from National Grid program vendor.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
MF Pipe Insulation	MF Retrofit	National Grid	1.00	1.00	1.00	n/a	n/a	n/a	n/a
MF Pipe Insulation	LI MF Retrofit	National Grid	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rate is 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

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

Multifamily – Shell Insulation

Version Date and Revision History

Effective Date: 1/1/2013
End Date: TBD

Measure Overview

Description: Shell insulation upgrades are applied in existing facilities including improved insulation in attics, basements and sidewalls.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Program: Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

$$MMBtu_{annual} = \frac{\left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) \times HDD \times 24 \times Area}{1{,}000{,}000 \times \eta_{heat}}$$

Where[670]:

Rexist	=	Existing effective R-value (R-ExistingInsulation + R-Assembly), ft2-°F/Btuh
Rnew	=	New total effective R-value (R-ProposedMeasure + R-ExistingInsulation + R-Assembly), ft2-°F/Btuh
Area	=	Square footage of insulated ceiling area
ηheat	=	Efficiency of the heating system-HSPF/COP
24	=	Conversion for hours per day
HDD	=	Heating Degree Days; dependent on location, see table below
1,000,000	=	Conversion from Btu to MMBtu

Baseline Efficiency

The baseline efficiency case is characterized by the total R-value of the existing attic, basement or sidewall (R_{exisit}). This is calculated as the R-value of the existing insulation, estimated by the program contractor, plus the R-value of the ceiling, floor, or wall (for all projects: $R_{CEILING} = 3.36$; $R_{FLOOR} = 6.16$; $R_{WALL} = 6.65$)[671].

[670] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.
[671] Savings assumptions from National Grid program vendor.

High Efficiency

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

Hours

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

HDD Values by Weather Station[672]

TMY3 City	HDD	CDH
Barnstable Muni Boa	4379	1349
Beverly Muni	5329	3432
Boston Logan Int'l Arpt	4550	4329
Chicopee Falls Westo	5016	4116
Lawrence Muni	4640	3978
Marthas Vineyard	4312	1345
Nantucket Memorial AP	3988	362
New Bedford Rgnl	4434	4232
North Adams	5234	2524
Norwood Memorial	4872	4763
Otis ANGBb	4718	2588
Plymouth Municipal	4559	2138
Provincetown (AWOS)	4368	2195
Westfield Barnes Muni AP	5301	3784
Worchester Regional Arpt	5816	1753

Measure Life

The measure life is 25 years.[673]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

[672] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators.
[673] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Insulation	MF Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Insulation	LI MF Retrofit	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rates are 100% based on no evaluations.

Coincidence Factors
There are no electric savings for this measure.

Multifamily – Outdoor Reset Control

Version Date and Revision History

Draft Date: 06/30/2011
Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Installation of outdoor reset controls in multi-family facilities.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Retrofit
End Use: HVAC
Program: Multifamily Retrofit, Low-Income Multifamily Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on program vendor assumptions:

$$\Delta MMBtu = AnnualHeatingConsumption \times \%SAVE \times \frac{1}{1{,}000{,}000}$$

Where:
AnnualHeatingConsumption = The total annual heating consumption for the facility (Btu)
%SAVE = Average reduction in energy consumption. See Table 44.
1/1,000,000 = Conversion from Btu to MMBtu

Table 44: Savings for MF Outdoor Reset Controls

Equipment Type	%SAVE[674]
Outdoor Reset Control	11%

Baseline Efficiency

The baseline efficiency case is the existing facility without an outdoor reset control. The existing facility is characterized by its average annual heating consumption as determined from the customers' billing data.

High Efficiency

The high efficiency case is the existing facility with a programmable thermostat installed.

[674] Savings assumptions from National Grid program vendor.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[675]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
MF SPACE Thermostat	MF Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
MF SPACE Thermostat	LI MF Retrofit	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 PA programs include verification of equipment installations.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
The energy realization rates are 100% based on no evaluations.

Coincidence Factors
Coincidence factors are not used since there are no electric savings counted for this measure.

[675] Environmental Protection Agency (2010). *Life-Cycle Assessment for Thermostats*.

Home Energy Services (Gas Weatherization) – Vendor Measures

Version Date and Revision History

Draft Date: 08/26/2011
Effective Date: 1/1/2012
End Date: TBD

Measure Overview

Description: Retrofit measures installed through the Home Energy Services program including: building envelope insulation, air sealing, and exterior doors.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential
Market: Retrofit
End Use: HVAC
Program: Home Energy Services (Gas Weatherization)

Notes: The impact evaluation conducted in 2011/2012 on the 2010 program year produced an average deemed savings per home for insulation and air sealing measures. These values are used for planning purposes but reported savings will be based on vendor calculated savings (see below). Additional work is being conducted in late 2012/early 2013 to develop realization rates that would be applied to the vendor estimate savings. The 2012 Report Version of the TRM will include these realization rates.

Algorithms for Calculating Primary Energy Impact

The Program Administrators use vendor calculated savings for measures in the Residential Home Energy Services gas 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. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly "adding" individual measure results.

Table 45: Deemed Therm Savings Used for Planning

Measure	ΔTherm[676]
Air Sealing	53
Insulation (overall)	96
Attic Insulation	77
Wall Insulation	99
Basement Insulation	14
Duct Insulation	68
Duct Sealing	36

Baseline Efficiency

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

High Efficiency

The high efficiency case includes installed energy efficiency measures that reduce heating energy use.

Hours

Hours are project-specific.

Measure Life

Measure	Measure Life (years)
Air Sealing	15[677]
Exterior Doors	25[678]
Shell Insulation	25[679]
Duct and Pipe Insulation	15[680]

Secondary Energy Impacts

There are no secondary energy impacts counted for these measures.

[676] The Cadmus Group, Inc. (2012). *Home Energy Services Impact Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts.
[677] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[678] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[679] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[680] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Air Sealing	HES	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Exterior Doors	HES	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Insulation	HES	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Duct and Pipe Insulation	HES	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factors.

Realization Rates
The energy realization rates are 100% based on no evaluations.

Coincidence Factors
Coincidence factors are not used since there are no electric savings counted for this measure.

Residential New Construction – Heating, Cooling, and DHW Measures

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: To capture lost opportunities, encourage the construction of energy-efficient homes, and drive the market to one in which new homes are moving towards net-zero energy.
Primary Energy Impact: Natural Gas (Residential Heat)
Secondary Energy Impact: Electric, Oil, Propane
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Residential, Low-Income
Market: Lost Opportunity
End Use: HVAC, Hot Water
Program: Residential New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Savings are derived from three components within this initiative, the Performance Path, the Prescriptive Path, and Hi-Rise Multi-Family building, four stories and higher.

For homes participating in the program via the Performance Path, projected energy use is calculated for each home completed through the program and a geometrically matching baseline home (User Defined Reference Home) using Beacon, an ICF International proprietary DOE-2 based building energy simulation tool. The difference between the projected energy consumption of these two homes represents the energy savings produced by the certified home. This process is used to calculate electric demand as well as electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes, both single family and multifamily for low rise buildings (three stories and below). This process is documented in "Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR® Homes Program."[681]

For homes participating in the program via the Prescriptive Path, deemed savings will be applied to each unit completing the requirements of the program. The deemed savings were derived by ICF International using modeling software to create a sample set of 168 homes that represented every type of home that would typically participate in the initiative, including various building types, sizes, fuel types, HVAC system types and climate locations.[682]

For homes participating in the Hi-Rise Multi-Family portion of the program ICF International created 98 customized engineering formulas for energy conservation measures spanning the following: Domestic Hot Water, Envelope, HVAC, Lighting, Refrigeration/Appliances and Motors & Drives.[683]

[681] ICF International (2008). *Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR ® Homes Program*. Prepared for Joint Management Committee.
[682] ICF International (2012). 2013 Prescriptive Modeling SummaryFinal – 082012.pdf
[683] ICF International (2012). 2013 Multifamily Savings Methodology.pdf

Baseline Efficiency

The User Defined Reference Home was revised for 2012 as a result of the baseline study completed in 2012.[684] [685]

High Efficiency

The high efficiency case is represented by the specific energy characteristics of each "as-built" home completed through the program.

Hours

Not applicable.

Measure Life

Measure Type	Measure Life (years)[686]
Cooling	25
Heating	25
Water Heating	15

Secondary Energy Impacts

Electric, Oil and Propane savings for heating and water heating measures are calculated using the same methodology described for the electric energy and demand savings.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts
One-Time Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
ES Homes – Cooling	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	1.00	0.00
ES Homes – Heating	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	0.00	1.00
ES Homes – Water Heating	RNC, LI RNC	All	1.00	1.00	1.00	1.00	1.00	0.89	1.00

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

Savings Persistence Factor

[684] NMR Group, Inc., KEMA, Inc., The Cadmus Group, Inc., Dorothy Conant (2012). *Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report*.
[685] NMR Group, Inc., KEMA, Inc., The Cadmus Group, Inc., Dorothy Conant (2012). *Final UDRH Inputs: Addendum to Massachusetts 2011 Baseline Study of Single-family Residential New Construction, Final Report*.
[686] Massachusetts Common Assumption.

All PAs use 100% savings persistence factors.

Realization Rates

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

Coincidence Factors

Coincidence factors are custom calculated based on project-specific detail.

Commercial and Industrial Gas Efficiency Measures

HVAC – Boilers

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: The installation of a high efficiency natural gas fired condensing hot water boiler. High-efficiency condensing boilers can take advantage of improved design, sealed combustion and condensing flue gases in a second heat exchanger to achieve improved efficiency.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency boiler
ΔMMBtu = Average annual MMBtu savings per unit. See Table 46 for values.

Table 46: Savings for C&I Boilers

Equipment Type	Size	Efficiency Requirement	ΔMMBtu 687,688
Condensing Boilers	<= 300 MBH	>= 90% AFUE	22.8
	301-499 MBH	>= 90% Thermal Efficiency	56.1
	500-999 MBH	>= 90% Thermal Efficiency	103.0
	1000-1700 MBH	>= 90% Thermal Efficiency	189.2
	1701+ MBH	>= 90% Thermal Efficiency	331.2
	<= 300 MBH	>= 96% AFUE	29.3

[687] KEMA (2012). *Prescriptive Gas Program Final Evaluation Report*. Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-2. Savings values for boilers <=300 MBH were proportioned based on increased 82% AFUE baseline efficiency in 10 CFR 430.
[688] 96% AFUE, <=300 MBH Boiler: Based on the formula found in Opinion Dynamics Corporation (2007). *Evaluation Study of KeySpan's Commercial and Industrial High Efficiency Heating Equipment Program.* Prepared for KeySpan Energy Delivery; Page 40, Gas savings = ((AFUEq-AFUEb)/AFUEq) x CAPY in therms/hour x EFLH. Assumed capacity of 165 MBH, 1500 EFLH, baseline of 80% going to 96% AFUE = 41.3 MMBTUs. Applied proportioning of savings based on KEMA 2011 and 2012 *Prescriptive Gas Program Final Evaluation Report* study, and increased 82% AFUE baseline efficiency in 10 CFR 430.

Baseline Efficiency

The baseline efficiency assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. The deemed savings methodology for this measure does not require specific baseline data, but the baseline information is provided here for use in the future when this is converted to a deemed calculated measure.

As described in Chapter 13 of the Massachusetts State Building Code, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2009. Table 47 details the specific efficiency requirements by equipment type and capacity.

Table 47: Baseline Efficiency Requirements for C&I Gas-Fired Boilers[689]

Equipment Type	Subcategory	Size Category (Input)	Minimum Efficiency[a]	Test Procedure
Boilers, hot water	Gas-Fired	<300,000 Btu/h	82% AFUE	10 CFR Part 430
		>=300,000 Btu/h and <=2,500,000 Btu/h[b]	80% E_t	10 CFR Part 431
		>2,500,000 Btu/h[c]	82% E_c	

a. Annual Fuel Utilization Efficiency (AFUE), Thermal efficiency (Et), Combustion efficiency (Ec)

b. Maximum capacity – min. and max. ratings as provided for and allowed by the units controls

c. These requirements apply to boilers with rated input of 8 MMBtu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers

High Efficiency

The high efficiency scenario assumes a gas-fired boiler that exceeds the efficiency levels required by Massachusetts State Building Code. Actual site efficiencies should be determined on a case-by-case basis.

Hours

Not applicable.

Measure Life

The measure life is 25 years.[690]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

[689] Adapted from 2009 International Energy Conservation Code; Table 503.2.3(5).
[690] ASHRAE Applications Handbook (2003); Page 36.3.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Boilers	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

HVAC – Boiler Reset Controls

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Program: C&I Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed boiler reset control
ΔMMBtu = Average annual MMBtu savings per unit: 35.5 MMBtu[691]

Baseline Efficiency

The baseline efficiency case is a boiler without reset controls.

High Efficiency

The high efficiency case is a boiler with reset controls.

Hours

Not applicable.

Measure Life

The measure life is 15 years.[692]

[691] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; the GDS Study assumes 710.46 MMBTU base use with 5% savings factor.
[692] ACEEE (2006). *Emerging Technologies Report: Advanced Boiler Controls*. Prepared for ACEEE; Page 2

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Boiler Reset Controls	C&I Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

HVAC – Combo Water Heater/Boiler

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC, Hot Water
Program: New Construction & Major Renovation Commercial

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency boiler/water heater combo units
ΔMMBtu = Average annual MMBtu savings per unit. See Table 48 for values.

Table 48: Savings for C&I Gas-Fired Combo Water Heater/Boilers

Measure	ΔMMBtu[693]
Combo Water Heater/Condensing Boiler (AFUE 90% and EF 0.90)	24.6

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 a condensing, integrated water heater/boiler with an AFUE of >=90%.

Hours

Not applicable.

[693] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks.

Measure Life

The measure life is 20 years.[694]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Combo Water Heater/Condensing Boiler (AFUE 90% and EF 0.90)	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[694] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks.

HVAC – Condensing Unit Heaters

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed condensing unit heater
ΔMMBtu = Average annual MMBtu savings per unit: 40.9 MMBtu[695]

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.[696]

High Efficiency

The high efficiency case is a condensing gas unit heater with 90% AFUE or greater.

Hours

Not applicable.

[695] NYSERDA Deemed Savings Database (Rev 11); Measure Name: A.UNIT-HEATER-COND.<300000.CI._._.N. The database provides savings of 204.6 MMBtu per million BTU/hr of heater input capacity. Assume average unit size of 200,000 BTU capacity.
[696] 2009 International Energy Conservation Code

Measure Life

The measure life is 18 years.[697]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Unit Heaters	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[697] Ecotrope, Inc. (2003). *Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial Sectors*. Prepared for the Energy Trust of Oregon.

HVAC – Furnaces

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: The installation of a high efficiency natural gas warm air furnace with an electronically commutated motor (ECM) for the fan. High efficiency furnaces are better at converting fuel into direct heat and better insulated to reduce heat loss. ECM fan motors significantly reduce fan motor electric consumption as compared to both shaped-pole and permanent split capacitor motors.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: Electric
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency furnace.
ΔMMBtu = Average annual MMBtu savings per unit. See Table 49 for values.

Table 49: Savings for C&I Gas-Fired Furnaces

Equipment Type	Efficiency	ΔMMBtu
Furnace (Forced Hot Air <150 kBTUh) w/ECM	AFUE = 95%	4.3 [698]
	AFUE = 97%	5.9 [699]

Baseline Efficiency

The baseline efficiency assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. The deemed savings methodology for this measure does not require specific baseline data, but the baseline information is provided here for use in the future if this is converted to a deemed calculated measure.

[698] KEMA (2012). *Prescriptive Gas Program Final Evaluation Report*. Prepared for Massachusetts Energy Efficiency Program Administrators; extrapolated from 92 to 94% savings on Page 1-3, and adjusted for 2013 change to 90% baseline efficiency.
[699] Ibid.

As described in the Massachusetts State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC). Table 50 details the specific efficiency requirements by equipment type and capacity.

Table 50: Baseline Efficiency Requirements for Gas-Fired Furnaces[700]

Equipment Type	Size Category (Input)	Minimum Efficiency
Warm air furnaces, gas fired	< 225,000 Btu/h	90% AFUE

High Efficiency

The high efficiency scenario assumes a gas-fired furnace equal or higher than the AFUE listed in Table 49.

Hours

Not applicable.

Measure Life

The measure life is 18 years.[701]

Secondary Energy Impacts

High efficiency furnaces equipped with ECM fan motors also save electricity from reduced fan energy requirements. The reduction of electric use is 168 kWh and 0.124 kW[702].

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Furnace (<150 MBH) AFUE 95% w/ECM	C&I NC	All	1.00	1.00	1.00	1.00	1.00	0.00	0.16
Furnace (<150 MBH) AFUE 97% w/ECM	C&I NC	All	1.00	1.00	1.00	1.00	1.00	0.00	0.16

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
All PAs use 100% energy realization rate.

Coincidence Factors

[700] 10 CFR 430, page 37548.
[701] ASHRAE Applications Handbook (2003); Page 36.3.
[702] ERS (2011) Pilot Evaluation of BFM DRAFT. Results as of 9/29/2011

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

HVAC – Infrared Heaters

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equipment. Infrared heating uses radiant heat as opposed to warm air to heat buildings. In commercial environments with high air exchange rates, heat loss is minimal because the space's heat comes from surfaces rather than air.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: HVAC
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed infrared heating unit
ΔMMBtu = Average annual MMBtu savings per unit: 48.3 MMBtu[703]

Baseline Efficiency

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

High Efficiency

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

Hours

Not applicable.

[703] KEMA (2012). *Prescriptive Gas Program Final Evaluation Report*. Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-4.

Measure Life

The measure life is 17 years.[704]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low-Intensity Infrared Heater	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[704] Nexant (2006). *DSM Market Characterization Report*. Prepared for Questar Gas.

HVAC – Thermostats

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of a 7-day programmable thermostat with the ability to adjust heating or air-conditioning operating times according to a pre-set schedule to meet occupancy needs and minimize redundant HVAC operation.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Program: C&I Retrofit, C&I Direct Install

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed programmable thermostat
ΔMMBtu = Average annual MMBtu reduction per unit: 7.7 MMBtu[705]

Baseline Efficiency

The baseline efficiency case is an HVAC system using natural gas to provide space heating without a programmable thermostat.

High Efficiency

The high efficiency case is an HVAC system using natural gas to provide space heating with a 7-day programmable thermostat installed.

Hours

Not applicable.

[705] RLW Analytics (2007). *Validating the Impact of Programmable Thermostats*. Prepared for GasNetworks; Page 2, conversion factor CCF to Therms is 1.024.

Measure Life

The measure life is 15 years.[706]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Thermostats	C&I Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Thermostats	C&I Direct Install	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[706] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*.

Hot Water – Water Heaters

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of a high-efficiency gas-fired water heater. *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. *Tankless water heaters* circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Hot water
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
ΔMMBtu = Average annual MMBtu savings per unit. See Table 51.

Table 51: Savings for C&I Water Heaters

Measure	2013 ΔMMBtu	2014 ΔMMBtu	2015 ΔMMBtu[707]
Condensing Stand-Alone water heater (75-300 MBH)	25.0[708]	25.0	23.5
Free-Standing Water Heater (EF 0.67)	3.0[709]	3.0	2.4
Indirect Water Heater (EF 0.82 and CAE 85%)	20.7[710]	20.7	20.7
On-demand Tankless Water Heater (EF 0.82)	7.1[711]	7.1	6.6
On-demand Tankless Water Heater (EF 0.94)	9.4[712]	9.4	9.0

Baseline Efficiency

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC). The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace.

For indirect, on-demand tankless and free-standing water heaters the 2013-2014 baseline is a code-compliant gas-fired storage water heater with EF = 0.59, whereas in 2015 the baseline EF = 0.61. For condensing stand-alone water heaters, the assumed baseline is a stand-alone tank water heater with a thermal efficiency of 80%.[713]

High Efficiency

Condensing Stand-Alone: The high efficiency case is a condensing stand alone commercial water heater with a thermal efficiency of 95% or greater and a capacity between 75,000 Btu and 300,000 Btu.
Free-Standing: The high efficiency case is an ENERGY STAR® gas-fired freestanding hot water heater with an Energy Factor of at least 0.67 and a nominal input of 75,000 BTU/hour or less.
Indirect: The high efficiency scenario is an indirect water heater with a Combined Appliance Efficiency (CAE) of 85% or greater.

[707] 2015 values adjusted based on baseline improvements in 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.
[708] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Page 2 of Appendix B-2, measure GDS C-WH-3. The GDS study references "ESource (2007). *Gas Fired Water Heater Screening Tool*. http://www.esource.com/BEA/demo/PDF/P_PA_41.pdf. Accessed on 10/22/10; used 0.96 Thermal Efficiency and 250 gallons per day."
[709] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Appendix B-2.
[710] KEMA (2012). *Prescriptive Gas Program Final Evaluation Report.* Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-4.
[711] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Page 2 of Appendix B-2, measure GDS C-WH-5. The GDS study references "FEMP Calculator for Electric & Gas Water Heaters (assumes 64 gal/day) Base use =27.1 MMBTU."
[712] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Page 2 of Appendix B-2, measure GDS C-WH-7, proportioned for 0.94 EF. The GDS study references "FEMP Calculator for Electric & Gas Water Heaters (assumes 64 gal/day) Base use =25.3 MMBTU."
[713] 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.

On-Demand Tankless: The high efficiency equipment is a gas-fired instantaneous hot water heater with an Energy Factor of at least 0.82.

Hours

Not applicable.

Measure Life

The measure lives for water heater vary by type as listed in the table below.

Table 52: Measure Lives for C&I Water Heaters

Equipment Type	Measure Life (years)
Condensing Stand-Alone Water Heater (75-300 MBH)	15 [714]
Free-Standing Water Heater	13 [715]
Indirect Water Heater	15 [716]
On-Demand Tankless Water Heater	20 [717]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Condensing Stand-Alone Water Heater (75-300 MBH)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Free-Standing Water Heater (EF 0.67)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Indirect Water Heater (EF 0.82 and CAE 85%)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
On-Demand Tankless Water Heater (EF 0.82)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
On-Demand Tankless Water Heater (EF 0.95)	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

[714] 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."
[715] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Appendix A-2.
[716] Ibid.
[717] Hewitt, D. Pratt, J. & Smith, G. (2005). *Tankless Gas Water Heaters: Oregon Market Status*. Prepared for the Energy Trust of Oregon.

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.

Hot Water – Pre-Rinse Spray Valve

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Retrofitting existing standard spray nozzles in locations where service water is supplied by natural gas fired hot water heater with new low flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: C&I Water, C&I Sewer
Sector: Commercial, Industrial
Market: Retrofit
End Use: Hot Water
Program: C&I Retrofit, C&I Direct Install

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed pre-rinse spray valve
ΔMMBtu = Average annual MMBtu savings per unit: 12.6 MMBtu[718]

Baseline Efficiency

The baseline efficiency case is a standard efficiency spray valve.

High Efficiency

The high efficiency case is a low flow pre-rinse spray valve with an average flow rate of 1.6 GPM.

Hours

Not applicable.

Measure Life

The measure life is 5 years.[719]

[718] Veritec Consulting (2005). *Region of Waterloo Pre-Rinse Spray Valve Pilot Study, Final Report*; Page 8
[719] Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings[720]
C&I Water	C&I water savings	23,617 gallons/unit
C&I Sewer	C&I sewer water savings	23,617 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Pre-Rinse Spray Valve	C&I Retrofit	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Pre-Rinse Spray Valve	C&I Direct Install	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[720] Ibid.

Hot Water – Steam Traps

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: Repair or replace malfunctioning steam traps.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Refer to Appendix C: Non-Resource Impacts
Sector: Commercial & Industrial
Market: Retrofit
End Use: HVAC
Program: C&I Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Repaired/replaced steam trap
ΔMMBtu = Average annual MMBtu savings per unit: 25.7 MMBtu[721]

Baseline Efficiency

The baseline efficiency case is a failed steam trap.

High Efficiency

The high efficiency case is a repaired or replaced steam trap.

Hours

Not applicable.

[721] National Grid 2008 based on historical steam trap surveys. Steam losses in lbs/hr are found using "Boiler Efficiency Institute (1987). *Steam Efficiency Improvement*.; Page 34, Table 4.1 under Steam Leak Rate Through Holes. Average loss rate for all trap sizes 1/32" to 1/4" for low steam pressures (5 psig and 10 psig) and high pressures (50 psig and 100 psig). Assume trap failure effective for 540 EFLH per year. Determine to equivalent therms per year and factor for frequency encountered = [80% * (78.50 + 111.46)/2] + [20% * (1,108.04 + 1,982.18)/2] = 385.01 BTU/trap-year. Assume that 50% of traps fail in the open position and savings is grossed up by the efficiency of the boiler supplying the steam of (inverse of 75%). Net savings is 257 therms per trap.

Measure Life

The measure life is 3 year.[722]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings
Annual Non-Resource	See Appendix C: Non-Resource Impacts	See Appendix C: Non-Resource Impacts

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Steam Traps	All	C&I Retrofit	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[722] Massachusetts Common Assumption. Most sources suggest a measure life or equipment life of five years. Massachusetts PAs have traditionally taken equipment life and applied a factor to account for measure persistence when determining measure life.

Hot Water – Low-Flow Shower Heads

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of a low flow showerhead with a flow rate of 1.5 GPM or less in a commercial setting with service water heated by natural gas.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: C&I Water, C&I Sewer
Sector: Commercial
Market: Retrofit
End Use: Hot water
Program: C&I Direct Install, C&I Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed low-flow shower head.
ΔMMBtu = Average annual MMBtu savings per unit: 5.2 MMBtu[723]

Baseline Efficiency

The baseline efficiency case is a 2.5 GPM showerhead.

High Efficiency

The high efficiency case is a 1.5 GPM showerhead.

Hours

The savings estimates for this measure are determined empirically in terms of units installed and so the equivalent heating full load hours are not directly used, however, the calculator used to determine the deemed savings uses a default operation of 20 minutes a day, 365 days a year.

[723] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Table B-2a, measure C-WH-15.

Measure Life

The measure life is 10 years.[724]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings[725]
C&I Water	C&I water savings	7,300 gallons/unit
C&I Sewer	C&I sewer water savings	7,300 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Low-Flow Shower Heads	C&I Direct Install	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[724] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Table B-2a, measure C-WH-15.
[725] US DOE-Federal Energy Management Program (FEMP): Energy Cost Calculator for Faucets and Showerheads. Accessed 9/13/2011.

Hot Water – Faucet Aerator

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of a faucet aerator with a flow rate of 1.5 GPM or less on an existing faucet with high flow in a commercial setting with service water heated by natural gas.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: C&I Water, C&I Sewer
Sector: Commercial
Market: Retrofit
End Use: Hot water
Program: C&I Direct Install, C&I Retrofit

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed faucet aerator
ΔMMBtu = Average annual MMBtu savings per unit: 1.7 MMBtu[726]

Baseline Efficiency

The baseline efficiency case is a 2.2 GPM faucet.

High Efficiency

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

Hours

The savings estimates for this measure are determined empirically in terms of units installed and so the equivalent heating full load hours are not directly used, however, the calculator used to determine the deemed savings uses a default operation of 30 minutes a day, 260 days a year.

[726] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Table B-2a, measure C-WH-16.

Measure Life

The measure life is 10 years.[727]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings[728]
C&I Water	C&I water savings	5,460 gallons/unit
C&I Sewer	C&I sewer water savings	5,460 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Faucet Aerator	C&I Direct Install	All	1.00	1.00	1.00	1.00	1.00	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[727] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Table B-2a, measure C-WH-16.
[728] US DOE-Federal Energy Management Program (FEMP): Energy Cost Calculator for Faucets and Showerheads. Accessed 9/13/2011.

Food Service – Commercial Ovens

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: Installation of High Efficiency Gas Ovens
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Water
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Process
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency gas oven
ΔMMBtu = Average annual MMBtu savings per unit. See Table 53 for values.

Table 53: Baseline and High Efficiency Ratings and Savings for C&I Ovens

Equipment Type	Baseline Efficiency	Efficiency Requirement	ΔMMBtu
Gas-Fired Convection Oven	30%	>= 44%	30.6[729]
Gas-Fired Combination Oven	35%	>= 44%	110.3 [730]
Gas-Fired Conveyer Oven	20% Heavy Load	>= 44%	84.5[731]
Gas-Fired Rack Oven	30%	>= 50%	211.3[732]

Baseline Efficiency

The baseline efficiency case is a standard efficiency oven. See Table 53 for values by oven type.

[729] Food Service Technology Center (2012). *Gas Convection Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/govencalc.php. Accessed 8/1/12.
[730] Food Service Technology Center (2010). *Gas Combination Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gcombicalc.php. Accessed 9/6/11.
[731] Food Service Technology Center (2010). *Gas Conveyor Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gconvovencalc.php. Accessed 6/10/10.
[732] Food Service Technology Center (2010). *Gas Rack Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/grackovencalc.php. Accessed 6/10/10.

High Efficiency

High efficiency case is an oven that meets or exceeds the high efficiency ratings per oven type shown in Table 53.

Hours

Not applicable.

Measure Life

The measure life is 12 years for all commercial ovens. [733]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

43,800 Gallons of water[734] for the combination oven

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Gas-Fired Convection Oven (>=40%)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Gas-Fired Combination Oven (>=40%)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Gas-Fired Conveyer Oven (>=40%)	C&I NC	All	1.00	1.00	1.00	n/a	n/a	n/a	n/a
Gas-Fired Rack Oven (>=50%)	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[733] Food Service Technology Center (2010). *Gas Combination Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gcombicalc.php. Accessed 6/10/10. AND Food Service Technology Center (2009). *Gas Rack Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/grackovencalc.php. Accessed on 6/10/10.
[734] Food Service Technology Center (2010). *Gas Combination Oven Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gcombicalc.php. Accessed 9/6/11.

Food Service – Commercial Griddle

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: Installation of a gas griddle with an efficiency of 38%.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Process
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency gas griddle.
ΔMMBtu = Average annual MMBtu savings per unit: 18.5 MMBtu[735]

Baseline Efficiency

The baseline efficiency case is a standard efficiency (30% efficient) gas griddle.

High Efficiency

The high efficiency case is a gas griddle with an efficiency of 38%.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[736]

[735] Food Service Technology Center (2010). *Gas Griddle Life-Cycle Cost Calculator.* http://www.fishnick.com/saveenergy/tools/calculators/ggridcalc.php. Accessed on 10/22/10.
[736] Ibid.

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Gas-Fired Griddle	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

Food Service – Commercial Fryer

Version Date and Revision History

Effective Date: 1/1/2011
End Date: TBD

Measure Overview

Description: The installation of a natural-gas fired fryer that is either ENERGY STAR® rated or has a heavy-load cooking efficiency of at least 50%. Qualified fryers use advanced burner and heat exchanger designs to use fuel more efficiently, as well as increased insulation to reduce standby heat loss.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: None
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Process
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

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

$$\Delta MMBtu = \left[\left(\frac{A_{BASE}}{\eta_{BASE}} + \left(B_{BASE} \times IDLE_{BASE}\right) + C_{BASE}\right) - \left(\frac{A_{EE}}{\eta_{EE}} + B_{EE}\left(IDLE_{EE}\right) + C_{EE}\right)\right]\left(\frac{365}{1{,}000{,}000}\right)$$

Where:

Unit	=	Installed high efficiency gas commercial fryer
ΔMMBtu	=	gross annual average MMBtu savings per unit: 58.6[737]
A_{BASE}	=	Baseline equipment daily cooking energy (Btu/day). Default = 85,500 Btu.
η_{BASE}	=	Baseline equipment heavy-load cooking efficiency. Default = 35%.
B_{BASE}	=	Baseline equipment daily fryer idle time (hours). Default = 13.25 hrs.
$IDLE_{BASE}$	=	Baseline equipment idle energy rate (Btu/h). Default = 14,000 Btu/h.
C_{BASE}	=	Baseline equipment total daily preheat energy (Btu). Default = 16,000 Btu.
A_{EE}	=	Efficient equipment daily cooking energy (Btu/day). Default = 85,500 Btu.
η_{EE}	=	Efficient equipment heavy-load cooking efficiency. Default = 55%
B_{EE}	=	Efficiency equipment daily fryer idle time (hours). Default 13.44 hrs.
$IDLE_{EE}$	=	Efficient equipment idle energy rate (Btu/h). Default = 8,500 Btu/hr.
C_{EE}	=	Efficient equipment daily total preheat energy (Btu). Default = 15,500 Btu.
365	=	Days per year.
1,000,000	=	Btu per MMBtu.

[737] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Gas Fryer*.

Baseline Efficiency

The baseline efficiency case is a typical low-efficiency gas-fired fryer with 35% cooking efficiency, 16,000 Btu preheat energy, 14,000 Btu/h Idle Energy Rate, 60 lbs/h production capacity[738].

High Efficiency

The high efficiency case cooking efficiency and Idle Energy Rate are site specific and can be determined on a case-by-case basis. To simplify the savings algorithm, typical values for food load (150 lbs/day) and preheat energy (15,500 Btu) are assumed.

Hours

Not applicable.

Measure Life

The measure life is 12 years.[739]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

There are no non-energy impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Gas-Fired Commercial Fryer	C&I NC	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.

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[738] Food Service Technology Center (2010). *Gas Fryer Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gfryercalc.php. Accessed on 10/19/2010.
[739] Ibid.

Food Service – Commercial Steamer

Version Date and Revision History

Effective Date: 1/1/2011 (Revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: The installation of an ENERGY STAR® rated natural-gas fired steamer, either connectionless or steam-generator design, with heavy-load cooking efficiency of at least 38%. Qualified steamers reduce heat loss due to better insulation, improved heat exchange, and more efficient steam delivery systems.
Primary Energy Impact: Natural Gas
Secondary Energy Impact: None
Non-Energy Impact: Water, Wastewater
Sector: Commercial & Industrial
Market: Lost Opportunity
End Use: Process
Program: C&I New Construction & Major Renovation

Algorithms for Calculating Primary Energy Impact

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

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency gas-fired steamer
ΔMMBtu = Average annual MMbtu savings per unit: 106.6 MMBtu

Baseline Efficiency

The baseline efficiency case is a typical boiler-based steamer with the following operating parameters: Preheat Energy rate = 72,000 Btu/hour, Idle Energy Rate = 18,000 Btu/hour, Heavy Load Efficiency = 18.0%, Production Capacity = 23.3 lbs/h/pan, Average Water Consumption Rate = 40 gal/h, and Percentage of Time in Constant Steam Mode = 40%.[740]

High Efficiency

The high efficiency case is an ENERGY STAR® qualified gas-fired steamer with the following operating parameters for a 6 pan steamer: Preheat Energy rate= 36,000 Btu/hour, Idle Energy Rate = 12,500 Btu/hour, Heavy Load Efficiency = 38.0%, Production Capacity = 20.0 lbs/h/pan, Average Water Consumption Rate = 3.0 gal/h, and Percentage of Time in Constant Steam Mode = 40%.[741]

[740] Environmental Protection Agency (2011). *Life Cycle Cost Estimate for ENERGY STAR Gas Steamer.* Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COF Accessed on 09/21/2011.
[741] Ibid.

Hours

The deemed savings assumes 4,380 annual operating hours (12 hours a day * 365 days/year).[742]

Measure Life

The measure life is 12 years.[743]

Secondary Energy Impacts

There are no secondary energy impacts for this measure.

Non-Energy Impacts

Benefit Type	Description	Savings[744]
C&I Water	C&I Water Savings	162,060 gallons/unit
C&I Wastewater	C&I Wastewater Savings	162,060 gallons/unit

Impact Factors for Calculating Adjusted Gross Savings

Measure Name	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Gas-Fired Steamer	C&I NC	All	1.00	1.00	1.00	1.00	1.00	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

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

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

[742] Ibid
[743] Ibid.
[744] Ibid.

Custom Measures

Version Date and Revision History

Effective Date: 1/1/2011 (revised for 1/1/2012)
End Date: TBD

Measure Overview

Description: The Custom project track is offered for energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering. Projects offered through the custom approach must pass a cost-effectiveness test based on project-specific costs and savings.
Primary Energy Impact: Natural Gas (Heating, Water Heating, or All)
Secondary Energy Impact: Project Specific
Non-Energy Impact: Project Specific
Sector: Commercial & Industrial
Market: Lost Opportunity, Retrofit
End Use: All
Program: All

Algorithms for Calculating Primary Energy Impact

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis and project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, or other engineering analysis and include estimates of savings, costs, and an evaluation of the project's cost-effectiveness.

Baseline Efficiency

For Lost Opportunity projects, the baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code or industry accepted standard practice.

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

High Efficiency

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis. The project must be proven cost-effective in order to qualify for energy efficiency incentives.

Hours

All hours for custom savings analyses should be determined on a case-by-case basis.

Measure Life

For both lost-opportunity and retrofit custom applications, the measure life is determined on a case-by-case basis.

Secondary Energy Impacts

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

Non-Energy Impacts

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

Impact Factors for Calculating Adjusted Gross Savings

Measure	Program	PA	ISR	SPF	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Custom NC	NC	Statewide	1.00	1.00	0.676	n/a	n/a	n/a	n/a
Custom NC	NC	NSTAR	1.00	1.00	0.473	n/a	n/a	n/a	n/a
Custom NC	NC	National Grid	1.00	1.00	0.685	n/a	n/a	n/a	n/a
Custom NC	NC	Columbia Gas	1.00	1.00	0.832	n/a	n/a	n/a	n/a
Custom Retrofit	Retrofit	Statewide	1.00	1.00	0.676	n/a	n/a	n/a	n/a
Custom Retrofit	Retrofit	NSTAR	1.00	1.00	0.473	n/a	n/a	n/a	n/a
Custom Retrofit	Retrofit	National Grid	1.00	1.00	0.685	n/a	n/a	n/a	n/a
Custom Retrofit	Retrofit	Columbia Gas	1.00	1.00	0.832	n/a	n/a	n/a	n/a

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

Savings Persistence Factor
All PAs use 100% savings persistence factor.

Realization Rates
Realization rates are from 2012 impact evaluation of 2010 Custom Gas installations[745]. NSTAR, National Grid and Columbia Gas use PA-specific results; all other PAs use the statewide result.

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

[745] KEMA ERS (2012). *Impact Evaluation of 2010 Custom Gas Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council; Page 8.

Appendices

Appendix A: Common Lookup Tables

Table 54: Lighting Power Densities Using the Building Area Method ($WATTS_{b,i}$)

Building Area Type	Lighting Power Density (W/ft^2) [746]	Lighting Power Density (W/ft^2) [747]
Automotive Facility	0.9	0.9
Convention Center	1.2	1.2
Court House	1.2	1.2
Dining: Bar Lounge/Leisure	1.3	1.3
Dining: Cafeteria/Fast Food	1.4	1.4
Dining: Family	1.6	1.6
Dormitory	1.0	1.0
Fire Stations	n/a	0.8
Exercise Center	1.0	1.0
Gymnasium	1.1	1.1
Healthcare-Clinic	1.0	1.0
Hospital	1.2	1.2
Hotel	1.0	1.0
Library	1.3	1.3
Manufacturing Facility	1.3	1.3
Motel	1.0	1.0
Motion Picture Theatre	1.2	1.2
Multi-Family	0.7	0.7
Museum	1.1	1.1
Office	1.0	0.9
Parking Garage	0.3	0.3
Penitentiary	1.0	1.0
Performing Arts Theatre	1.6	1.6
Police/Fire Station	1.0	1.0
Post Office	1.1	1.1
Religious Building	1.3	1.3
Retail	1.5	1.4
School/University	1.2	1.2
Sports Arena	1.1	1.1
Town Hall	1.1	1.1
Transportation	1.0	1.0
Warehouse	0.8	0.6
Workshop	1.4	1.4

[746] IECC 2009 Lighting Provisions, Section 505 Electrical Power and Lighting Systems, Table 505.5.2 Interior Lighting Power Allowances, Lighting provisions pgs.5-6.
[747] IECC 2012

Table 55: Lighting Power Densities Using the Space-by-Space Method ($WATTS_{b,i}$)[748]

Common Space Types	Lighting Power Density (W/ft^2)
Office – Enclosed	1.1
Office - Open Plan	1.1
Conference/Meeting/Multipurpose	1.3
Classroom/Lecture/Training	1.4
For Penitentiary	1.3
Lobby	1.3
For Hotel	1.1
For Performing Arts Theater	3.3
For Motion Picture Theater	1.1
Audience/Seating Area	0.9
For Gymnasium	0.4
For Exercise Center	0.3
For Convention Center	0.7
For Penitentiary	0.7
For Religious Buildings	1.7
For Sports Arena	0.4
For Performing Arts Theater	2.6
For Motion Picture Theater	1.2
For Transportation	0.5
Atrium - First Three Floors	0.6
Atrium - Each Additional Floor	0.2
Lounge/Recreation	1.2
For Hospital	0.8
Dining Area	0.9
For Penitentiary	1.3
For Hotel	1.3
For Motel	1.2
For Bar Lounge/Leisure Dining	1.4
For Family Dining	2.1
Food Preparation	1.2
Laboratory	1.4
Restrooms	0.9
Dressing/Locker/Fitting Room	0.6
Corridor/Transition	0.5
For Hospitals	1.0
For Manufacturing Facilities	0.5
Stairs – Active	0.6
Active Storage	0.8
For Hospital	0.9
Inactive Storage	0.3
For Museum	0.8
Electrical/Mechanical	1.5

[748] ASHRAE 90.1-2007 Energy Standard for Building Except Low-Rise Residential Buildings, Table 9.6.1, pp.63-64.

Common Space Types	Lighting Power Density (W/ft^2)
Gymnasium/Exercise Center	
Exercise Area	0.9
Playing Area	1.4
Court House/Police Station/Penitentiary	
Courtroom	1.9
Confinement Cells	0.9
Judges Chambers	1.3
Fire Stations	
Engine Room	0.8
Sleeping Quarters	0.3
Post Office – Sorting Area	1.2
Convention Center - Exhibit Space	1.3
Library	
Card File and Cataloging	1.1
Stacks	1.7
Reading Area	1.2
Hospital	
Emergency	2.7
Recovery	0.8
Nurses' Station	1.0
Exam/Treatment	1.5
Pharmacy	1.2
Patient Room	0.7
Operating Room	2.2
Nursery	0.6
Medical Supply	1.4
Physical Therapy	0.9
Radiology	0.4
Laundry-Washing	0.6
Automobile - Service/Repair	0.7
Manufacturing	
Low Bay (< 25 ft. Floor to Ceiling Height)	1.2
High Bay (≥ 25 ft. Floor to Ceiling Height)	1.7
Detailed Manufacturing	2.1
Equipment Room	1.2
Control Room	0.5
Hotel/Motel Guest Rooms	1.1
Dormitory - Living Quarters	1.1
Museum	
General Exhibition	1.0
Restoration	1.7
Bank/Office - Banking Activity Areas	1.5
Workshop	1.9
Sales Area [for accent lighting, see Section 9.6.2(b)]	1.7
Religious Buildings	
Worship Pulpit, Choir	2.4

Common Space Types	**Lighting Power Density (W/ft^2)**
Fellowship Hall	0.9
Retail	
Sales Area [for accent lighting, see Section 9.6.3(c)]	1.7
Mall Concourse	1.7
Sports Arena	
Ring Sports Arena	2.7
Court Sports Arena	2.3
Indoor Playing Field Area	1.4
Warehouse	
Fine Material Storage	1.4
Medium/Bulky Material Storage	0.9
Parking Garage - Garage Area	0.2
Transportation	
Airport – Concourse	0.6
Airport/Train/Bus - Baggage Area	1.0
Terminal - Ticket Counter	1.5

Table 46a: Lighting Power Densities Using the Space-by-Space Method ($WATTS_{b,i}$)[749]

Common Space Types	Lighting Power Density (W/ft^2)
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating	
For Auditorium	0.9
For performing arts theater	2.6
For motion picture theater	1.2
Classroom/lecture/training	1.30
Conference/meeting/multipurpose	1.2
Corridor/transition	0.7
Dining Area	0.9
Bar/lounge/leisure dining	1.40
Family dining area	1.40
Dressing/fitting room performing arts theater	1.1
Electrical/mechanical	1.10
Food preparation	1.20
Laboratory for classrooms	1.3
Laboratory for medical/industrial/research	1.8
Lobby	1.10
Lobby for performing arts theater	3.3
Lobby for motion picture theater	1.0
Locker room	0.80
Lounge/Recreation	0.8
Office - enclosed	1.1
Office – open plan	1.0
Restroom	1.0
Sales area	1.6
Stairway	0.70
Storage	0.8
Workshop	1.60
Courthouse/police station/penitentiary	
Courtroom	1.90
Confinement cells	1.1
Judge Chambers	1.30
Penitentiary audience seating	0.5
Penitentiary classroom	1.3
Penitentiary dining	1.1
BUILDING SPECIFIC SPACE-BY-SPACE TYPES	
Automotive – service/repair	0.70
Bank/office – banking activity area	1.5
Dormitory living quarters	1.10
Gymnasium/fitness center	
Fitness area	0.9

[749] IECC 2012.

Common Space Types	Lighting Power Density (W/ft^2)
Gymnasium audience/seating	0.40
Playing area	1.40
COMMON SPACE-BY-SPACE TYPES	1.4
Healthcare clinic/hospital	
Corridors/transition	1.00
Exam/treatment	1.70
Emergency	0.80
Public and staff lounge	0.80
Medical Supplies	1.40
Nursery	0.9
Nurse Station	1.00
Physical Therapy	0.9
Patient room	0.70
Pharmacy	1.20
Radiology/imaging	1.3
Operating room	2.20
Recovery	1.2
Lounge Recreation	0.8
Laundry – washing	0.60
Hotel	
Dining area	1.30
Guest rooms	1.10
Hotel lobby	2.10
Highway lodging dining	1.20
Highway lodging guest rooms	1.10
Library	
Stacks	1.70
Card File and cataloguing	1.10
Reading area	1.20
Manufacturing	
Corridors/transition	0.40
Detailed Manufacturing	1.3
Equipment Room	1.0
Extra high bay (> 50-foot floor-ceiling height)	1.1
High bay (25 – 50-foot floor-ceiling height)	1.20
Low bay (< 25-foot floor-ceiling height)	1.20
Museum	
General Exhibition	1.00
Restoration	1.70
Parking Garage – garage areas	0.2
Convention Center	
Exhibit space	1.50
Audience/seating area	0.90
Fire Stations	
Engine Room	0.80
Sleeping quarters	0.30

Common Space Types	**Lighting Power Density (W/ft^2)**
Post Office	
Sorting area	0.90
Religious building	
Fellowship hall	0.60
Audience seating	2.40
Worship pulpit/choir	2.40
Retail	
Dressing/fitting area	0.9
Mall concourse	1.6
Sales area	1.6
BUILDING SPECIFIC SPACE-BY-SPACE TYPES	
Sports areana	
Audience seating	0.4
Court sports area – Class 4	0.7
Court sports area – Class 3	1.2
Court sports area – Class 2	1.9
Court sports area – Class 1	3.0
Ring sports area	2.7
Transportation	
Air/train/bus baggage area	1.00
Airport concourse	0.60
Terminal – ticket counter	1.50
Warehouse	
Fine material storage	1.40
Medium/bulky material	0.60

Table 56: MassSAVE New Construction Proposed Lighting Wattage Tables

2012 MassSAVE C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

Device Code	Device Description	Rated Watts
LED Exit Signs		
1E0002	2.0 WATT LED	2
1E0003	3.0 WATT LED	3
1E0005	5.0 WLED	5
1E0005C	0.5 WATT LEC	0.5
1E0008	8.0 WLED	8
1E0015	1.5 WATT LED	1.5
1E0105	10.5 WATT LED	10.5
Compact Fluorescents (CFL's)		
2C0007S	2/7W COMPACT HW	18
1C0005S	5W COMPACT HW	7
1C0007S	7W COMPACT HW	9
1C0009S	9W COMPACT HW	11
1C0011S	11W COMPACT HW	13
1C0013S	13W COMPACT HW	15
1C0018E	18W COMPACT HW ELIG	20
1C0018S	18W COMPACT HW	20
1C0022S	22W COMPACT HW	24
1C0023E	1/23W COMPACT HW ELIG	25
1C0026E	26W COMPACT HW ELIG	28
1C0026S	26W COMPACT HW	28
1C0028S	28W COMPACT HW	30
1C0032E	32W COMPACT HW ELIG	34
1C0032S	32W CIRCLINE HW	34
1C0042E	1/42W COMPACT HW ELIG	48
1C0044S	44W CIRCLINE HW	46
1C0057E	1/57W COMPACT HW ELIG	65
1C2232S	22/32W CIRCLINE HW	58
1C2D10E	10W 2D COMPACT HW ELIG	12
1C2D16E	16W 2D COMPACT HW ELIG	18
1C2D21E	21W 2D COMPACT HW ELIG	22
1C2D28E	28W 2D COMPACT HW ELIG	28
1C2D38E	38W 2D COMP.HW ELIG	36
1C3240S	32/40W CIRCLINE HW	80
2C0005S	2/5W COMPACT HW	14
2C0009S	2/9W COMPACT HW	22
2C0011S	2/11W COMPACT HW	26
2C0013E	2/13W COMPACT HW ELIG	28
2C0013S	2/13W COMPACT HW	30
2C0018E	2/18W COMP. HW ELIG	40
2C0026E	2/26W COMP. HW ELIG	54
2C0032E	2/32W COMPACT HW ELIG	68

Device Code	Device Description	Rated Watts
Compact Fluorescents (CFL's) (cont)		
2C0042E	2/42W COMPACT HW ELIG	100
3C0009S	3/9W COMPACT HW	33
3C0013S	3/13W COMPACT HW	45
3C0018E	3/18W COMPACT HW ELIG	60
3C0026E	3/26W COMPACT HW ELIG	82
3C0032E	3/32W COMPACT HW ELIG	114
3C0042E	3/42W COMPACT HW ELIG	141
4C0018E	4/18W COMPACT HW ELIG	80
4C0026E	4/26W COMPACT HW ELIG	108
4C0032E	4/32W COMPACT HW ELIG	152
4C0042E	4/42W COMPACT HW ELIG	188
6C0026E	6/26W COMPACT HW ELIG	162
6C0032E	6/32W COMPACT HW ELIG	228
6C0042E	6/42W COMPACT HW ELIG	282
8C0026E	8/26W COMPACT HW ELIG	216
8C0032E	8/32W COMPACT HW ELIG	304
8C0042E	8/42W COMPACT HW ELIG	376
T5 Systems		
1F14SSE	1L2' 14W T5/ELIG	16
2F14SSE	2L2' 14W T5/ELIG	32
3F14SSE	3L2' 14W T5/ELIG	50
4F14SSE	4L2' 14W T5/ELIG	68
1F24HSE	1L2' 24W T5HO/ELIG	29
2F24HSE	2L2' 24W T5HO/ELIG	52
3F24HSE	3L2' 24W T5HO/ELIG	80
1F21SSE	1L3' 21W T5/ELIG	24
2F21SSE	2L3' 21W T5/ELIG	47
1F39HSE	1L3' 39W T5HO/ELIG	42
2F39HSE	2L3' 39W T5HO/ELIG	85
1F28SSE	1L4' 28W T5/ELIG	32
2F28SSE	2L4' 28W T5/ELIG	63
3F28SSE	3L4' 28W T5/ELIG	95
4F28SSE	4L4' 28W T5/ELIG	126
6F28SSE	6L4' 28W T5/ELIG	189
1F47HSE	1L4' 47W T5HO/ELIG	53
2F47HSE	2L4' 47W T5HO/ELIG	103
3F47HSE	3L4' 47W T5HO/ELIG	157
4F47HSE	4L4' 47W T5HO/ELIG	200
5F47HSE	5L4' 47W T5HO/ELIG	260
6F47HSE	6L4' 47W T5HO/ELIG	303
1F50HSE	1L4' 50W T5HO/ELIG	58
2F50HSE	2L4' 50W T5HO/ELIG	110

Device Code	Device Description	Rated Watts
	T5 Systems (cont.)	
3F50HSE	3L4' 50W T5HO/ELIG	168
4F50HSE	4L4' 50W T5HO/ELIG	215
5F50HSE	5L4' 50W T5HO/ELIG	278
6F50HSE	6L4' 50W T5HO/ELIG	325
1F54HSE	1L4' 54W T5HO/ELIG	59
2F54HSE	2L4' 54W T5HO/ELIG	117
3F54HSE	3L4' 54W T5HO/ELIG	177
4F54HSE	4L4' 54W T5HO/ELIG	234
5F54HSE	5L4' 54W T5HO/ELIG	294
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
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

Device Code	Device Description	Rated Watts
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
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

Device Code	Device Description	Rated Watts
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
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
6F32EEH	6L4' 32W T8EE/ELEE HIGH PWR	218
6F32EEE	6L4' 32W T8EE/ELEE	168
6F32EEL	6L4' 32W T8EE/ELEE LOW PWR	146
Eight Foot T8 Systems		
1F59SSE	1L8' T8/ELIG	60
1F80SSE	1L8' T8 HO/ELIG	85
2F59SSE	2L8' T8/ELIG	109
2F59SSL	2L8' T8/ELIG LOW PWR	100
2F80SSE	2L8' T8 HO/ELIG	160
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	04
1L005	5 WATT LED	05
1L006	6 WATT LED	06
1L007	7 WATT LED	07
1L008	8 WATT LED	08
1L009	9 WATT LED	09
1L010	10 WATT LED	10
1L011	11 WATT LED	11
1L012	12 WATT LED	12

Device Code	Device Description	Rated Watts
LED Lighting Fixtures (cont.)		
1L013	13 WATT LED	13
1L014	14 WATT LED	14
1L015	15 WATT LED	15
1L016	16 WATT LED	16
1L017	17 WATT LED	17
1L018	18 WATT LED	18
1L019	19 WATT LED	19
1L020	20 WATT LED	20
1L021	21 WATT LED	21
1L022	22 WATT LED	22
1L023	23 WATT LED	23
1L024	24 WATT LED	24
1L025	25 WATT LED	25
1L026	26 WATT LED	26
1L027	27 WATT LED	27
1L028	28 WATT LED	28
1L029	29 WATT LED	29
1L030	30 WATT LED	30
1L031	31 WATT LED	31
1L032	32 WATT LED	32
1L033	33 WATT LED	33
1L034	34 WATT LED	34
1L035	35 WATT LED	35
1L036	36 WATT LED	36
1L037	37 WATT LED	37
1L038	38 WATT LED	38
1L039	39 WATT LED	39
1L040	40 WATT LED	40
1L041	41 WATT LED	41
1L042	42 WATT LED	42
1L043	43 WATT LED	43
1L044	44 WATT LED	44
1L045	45 WATT LED	45
1L046	46 WATT LED	46
1L047	47 WATT LED	47
1L048	48 WATT LED	48
1L049	49 WATT LED	49
1L050	50 WATT LED	50
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L070	70 WATT LED	70
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

Device Code	Device Description	Device Code
LED Lighting Fixtures (cont.)		
1L095	95 WATT LED	95
1L100	100 WATT LED	100
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
1L135	135 WATT LED	135
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
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
1L190	190 WATT LED	190
1L200	200 WATT LED	200

Device Code	Device Description	Device Code
LED Lighting Fixtures (cont.)		
1L210	210 WATT LED	210
1L220	220 WATT LED	220
1L240	240 WATT LED	240
Electronic Metal Halide Lamps		
1M0150E	150W METAL HALIDE EB	160
1M0200E	200W METAL HALIDE EB	215
1M0250E	250W METAL HALIDE EB	270
1M0320E	320W METAL HALIDE EB	345
1M0350E	350W METAL HALIDE EB	375
1M0400E	400W METAL HALIDE EB	430
1M0450E	400W METAL HALIDE EB	480
MH Track Lighting		
1M0020E	20W MH SPOT	25
1M0025E	25W MH SPOT	25
1M0035E	35W MH SPOT	44
1M0039E	39W MH SPOT	47
1M0050E	50W MH SPOT	60
1M0070E	70W MH SPOT	80
1M0100E	100W MH SPOT	111
1M0150E	150W MH SPOT	162

Table 57: MassSAVE Retrofit Existing Lighting Wattage Tables

2012 MassSAVE C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

Device Code	Device Description	Rated Watts
Incandescent Lamps		
1I0015	15W INC	15
1I0020	20W INC	20
1I0025	25W INC	25
1I0034	34W INC	34
1I0036	36W INC	36
1I0040	40W INC	40
1I0042	42W INC	42
1I0045	45W INC	45
1I0050	50W INC	50
1I0052	52W INC	52
1I0054	54W INC	54
1I0055	55W INC	55
1I0060	60W INC	60
1I0065	65W INC	65
1I0067	67W INC	67
1I0069	69W INC	69
1I0072	72W INC	72
1I0075	75W INC	75
1I0080	80W INC	80
1I0085	85W INC	85
1I0090	90W INC	90
1I0093	93W INC	93
1I0100	100W INC	100
1I0120	120W INC	120
1I0125	125W INC	125
1I0135	135W INC	135
1I0150	150W INC	150
1I0200	200W INC	200
1I0300	300W INC	300
1I0448	448W INC	448
1I0500	500W INC	500
1I0750	750W INC	750
1I1000	1000W INC	1000
1I1500	1500W INC	1500
Low Voltage Halogen Fixture (includes Transformer)		
1R0020	20W LV HALOGEN FIXT	30
1R0025	25W LV HALOGEN FIXT	35
1R0035	35W LV HALOGEN FIXT	45
1R0042	42W LV HALOGEN FIXT	52
1R0050	50W LV HALOGEN FIXT	60
1R0065	65W LV HALOGEN FIXT	75
Device Code	**Device Description**	**Rated Watts**
Low Voltage Halogen Fixture (includes Transformer) (cont.)		
1R0075	75W LV HALOGEN FIXT	85
Halogen/Quartz Lamps		
1T0035	35W HALOGEN LAMP	35
1T0040	40W HALOGEN LAMP	40
1T0042	42W HALOGEN LAMP	42
1T0045	45W HALOGEN LAMP	45
1T0047	47W HALOGEN LAMP	47
1T0050	50W HALOGEN LAMP	50
1T0052	52W HALOGEN LAMP	52
1T0055	55W HALOGEN LAMP	55
1T0060	60W HALOGEN LAMP	60
1T0072	72W HALOGEN LAMP	72
1T0075	75W HALOGEN LAMP	75
1T0090	90W HALOGEN LAMP	90
1T0100	100W HALOGEN LAMP	100
1T0150	150W HALOGEN LAMP	150
1T0200	200W HALOGEN LAMP	200
1T0250	250W HALOGEN LAMP	250
1T0300	300W HALOGEN LAMP	300
1T0350	350W HALOGEN LAMP	350
1T0400	400W HALOGEN LAMP	400
1T0425	425W HALOGEN LAMP	425
1T0500	500W HALOGEN LAMP	500
1T0750	750W HALOGEN LAMP	750
1T0900	900W HALOGEN LAMP	900
1T1000	1000W HALOGEN LAMP	1000
1T1200	1200W HALOGEN LAMP	1200
1T1500	1500W HALOGEN LAMP	1500
Mercury Vapor (MV)		
1V0040S	40W MERCURY	50
1V0050S	50W MERCURY	75
1V0075S	75W MERCURY	95
1V0100S	100W MERCURY	120
1V0175S	175W MERCURY	205
1V0250S	250W MERCURY	290
1V0400S	400W MERCURY	455
1V0700S	700W MERCURY	775
1V1000S	1000W MERCURY	1075

2V0400S	2/400W MERCURY	880
Device Code	**Device Description**	**Rated Watts**
Low Pressure Sodium (LPS)		
1L0035S	35W LPS	60
1L0055S	55W LPS	85
1L0090S	90W LPS	130
1L0135S	135W LPS	180
1L0180S	180W LPS	230
High Pressure Sodium (HPS)		
1H0035S	35W HPS	45
1H0050S	50W HPS	65
1H0070S	70W HPS	90
1H0100S	100W HPS	130
1H0150S	150W HPS	190
1H0200S	200W HPS	240
1H0225S	225W HPS	275
1H0250S	250W HPS	295
1H0310S	310W HPS	350
1H0360S	360W HPS	435
1H0400S	400W HPS	460
1H0600S	600W HPS	675
1H0750S	750W HPS	835
1H1000S	1000W HPS	1085
Metal Halide (MH)		
1M0032S	32W METAL HALIDE	40
1M0050S	50W METAL HALIDE	65
1M0070S	70W METAL HALIDE	95
1M0100S	100W METAL HALIDE	120
1M0150S	150W METAL HALIDE	190
1M0175S	175W METAL HALIDE	205
1M0250S	250W METAL HALIDE	295
1M0360S	360W METAL HALIDE	430
1M0400S	400W METAL HALIDE	455
1M0750S	750W METAL HALIDE	825
1M1000S	1000W METAL HALIDE	1075
1M1500S	1500W METAL HALIDE	1615
1M1800S	1800W METAL HALIDE	1875
Pulse Start Metal Halide Lamp/Ballast		
1M0100P	100W MH CWA	128
1M0100R	100W MH LINEAR	118
1M0150P	150W MH CWA	190
1M0150R	150W MH LINEAR	172
1M0175P	175W MH CWA	208
1M0175R	175W MH LINEAR	190

1M0200P	200W MH CWA	232
Device Code	**Device Description**	**Rated Watts**
Pulse Start Metal Halide Lamp/Ballast (cont.)		
1M0200R	200W MH LINEAR	218
1M0250P	250W MH CWA	288
1M0250R	250W MH LINEAR	265
1M0300P	300W MH CWA	342
1M0300R	300W MH LINEAR	324
1M0320P	320W MH CWA	365
1M0320R	320W MH LINEAR	345
1M0350P	350W MH CWA	400
1M0350R	350W MH LINEAR	375
1M0400P	400W MH CWA	455
1M0400R	400W MH LINEAR	430
1M0450P	450W MH CWA	508
1M0450R	450W MH LINEAR	480
1M0750P	750W MH CWA	815
1M0750R	750W MH LINEAR	805
1M0875P	875W MH CWA	950
1M0875R	875W MH LINEAR	927
1M1000P	1000W MH CWA	1080
Two Foot T8 / T12 Systems		
1F20SSS	F20T12/HPF(1)	32
1F80BXE	1L2' F80BXE/ELIG	90
1F55BXE	1L2' F55BX/ELIG	56
2F17SSE	2L2' 17W T8/ELIG	37
2F17SSL	2L2' 17W T8/ELIG LOW POWER	27
2F17SSM	2L2' 17W T8/EEMAG	45
2F20SSS	F20T12/HPF(2)	56
2F24HSS	2L2' 24 T12HO/STD/STD	85
2F40BXE	2L2' F40BX/ELIG	72
2F50BXE	2L2' F50BX/ELIG	108
2F55BXE	2L2'55BXE/ELIG	112
3F17SSE	3L2' 17W T8/ELIG	53
3F17SSL	3L2' 17W T8/ELIG LOW POWER	39
3F20SSS	F20T12/HPF(3)	78
3F40BXE	3L2' F40BX/ELIG	102
3F50BXE	3L2' F50BX/ELIG	162
3F55BXE	3L2' F55BX/ELIG	168
4F17SSE	4L2' 17W T8/ELIG	62
4F36BXE	4L2' F36BX/ELIG	148
4F40BXE	4L2' F40BX/ELIG	144
4F40BXH	4L 40W T5 (Std.) HIGH LMN	170
4F50BXE	4L2' F50BX/ELIG	216
4F55BXE	4L2' F55BX/ELIG	224

5F40BXE	5L2' F40BX/ELIG	190

Device Code	Device Description	Rated Watts
Two Foot T8 / T12 Systems (cont.)		
5F50BXE	5L2' F50BX/ELIG	270
5F55BXE	5L2' F55BX/ELIG	280
6F36BXE	6L2' F36BX/ELIG	212
6F40BXE	6L2' F40BX/ELIG	204
6F50BXE	6L2' F50BX/ELIG	324
6F55BXE	6L2' F55BX/ELIG	336
8F36BXE	8L2' F36BX/ELIG	296
8F40BXE	8L2' F40BX/ELIG	288
8F50BXE	8L2' F50BX/ELIG	432
8F55BXE	8L2' F55BX/ELIG	448
9F36BXE	9L2' F36BX/ELIG	318
9F40BXE	9L2' F40BX/ELIG	306
9F50BXE	9L2' F50BX/ELIG	486
9F55BXE	9L2' F55BX/ELIG	504
12F40BE	12L2' F40BX/ELIG	408
12F50BE	12L2' F50BX/ELIG	648
12F55BE	12L2' F55BX/ELIG	672
Three Foot T8 / T12 Systems		
1F30SEM	1L3' 30W T12 EE/EEMAG	38
1F30SES	1L3' 30W T12 EE/STD	42
1F30SSS	1L3' 30W T12 STD/STD	46
1F25SSE	1L3' 25W T8/ELIG	24
1F25SSH	1L3' 25W T8/ELIG HIGH LMN	28
2F30SEE	2L3' 30W T12 EE/ELIG	49
2F30SEM	2L3' 30W T12 EE/EEMAG	66
2F30SES	2L3' 30W T12 EE/STD	73
2F30SSS	2L3' 30W T12 STD/STD	80
2F25SSE	2L3' 25W T8/ELIG	47
2F25SSM	2L3' 25W T8/EEMAG	65
3F30SSS	3L3' 30W T12 STD/STD	140
3F30SES	3L3' 30W T12 EE/STD	127
3F25SSE	3L3' 25W T8/ELIG	68
4F25SSE	4L3' 25W T8/ELIG	88
Four Foot F48 T8 Systems		
1F48SES	1L4' F48T12EE/STD	50
1F48SSS	1L4' F48T12/STD	60
2F48SES	2L4' F48T12EE/STD	82
2F48SSS	2L4' F48T12/STD	102
3F48SES	3L4' F48T12EE/STD	132
3F48SSS	3L4' F48T12/STD	162
4F48SES	4L4' F48T12EE/STD	164
4F48SSS	4L4' F48T12/STD	204

Device Code	Device Description	Rated Watts
Four Foot F48HO T8 Systems		
1F48HES	1L4' F48HO/EE/STD	80
1F48HSS	1L4' F48H0/STD/STD	85
2F48HES	2L4' F48HO/EE/STD	135
2F48HSS	2L4' F48H0/STD/STD	145
3F48HES	3L4' F48HO/EE/STD	215
3F48HSS	3L4' F48H0/STD/STD	230
4F48HES	4L4' F48HO/EE/STD	270
4F48HSS	4L4' F48H0/STD/STD	290
Four Foot F48VHO T12 Systems		
1F48VES	1L4' F48VHO/EE/STD	123
1F48VSS	1L4' F48VHO/STD/STD	138
2F48VES	2L4' F48VHO/EE/STD	210
2F48VSS	2L4' F48VHO/STD/STD	240
3F48VES	3L4' F48VHO/EE/STD	333
3F48VSS	3L4' F48VHO/STD/STD	378
4F48VES	4L4' F48VHO/EE/STD	420
4F48VSS	4L4' F48VHO/STD/STD	480
Four Foot T12 Systems		
1F40SEE	1L4' EE/ELIG	38
1F40SEM	1L4' EE/EEMAG	40
1F40SES	1L4' EE/STD	50
1F40SSE	1L4' STD/ELIG	46
1F40SSM	1L4' STD/EEMAG	50
1F40SSS	1L4' STD/STD	57
1F40HSE	1L4' HO/STD/ELIG	59
2F40SEE	2L4' EE/ELIG	60
2F40SEM	2L4' EE/EEMAG	70
2F40SES	2L4' EE/STD	80
2F40SSE	2L4' STD/ELIG	72
2F40SSM	2L4' STD/EEMAG	86
2F40SSS	2L4' STD/STD	94
3F40SEE	3L4' EE/ELIG	90
3F40SEM	3L4' EE/EEMAG	110
3F40SES	3L4' EE/STD	130
3F40SSE	3L4' STD/ELIG	110
3F40SSM	3L4' STD/EEMAG	136
3F40SSS	3L4' STD/STD	151
4F40SEE	4L4' EE/ELIG	120
4F40SEM	4L4' EE/EEMAG	140
4F40SES	4L4' EE/STD	160
4F40SSE	4L4' STD/ELIG	144
4F40SSM	4L4' STD/EEMAG	172

Device Code	Device Description	Rated Watts
4F40SSS	4L4' STD/STD	188
Four Foot T12 Systems (cont.)		
6F40SSS	6L4' STD/STD	282
Four Foot T8 Systems		
1F32SSE	1L4' T8/ELIG	30
1F32SSL	1L4' T8/ELIG LOW POWER	26
1F32SSM	1L4' T8/EEMAG	37
1F32SSH	1L4' T8/ELIG HIGH LMN	36
2F32SSE	2L4' T8/ELIG	60
2F32SSH	2L4' T8/ELIG HIGH LMN	78
2F32SSL	2L4' T8/ELIG LOW PWR	52
2F32SSM	2L4' T8/EEMAG	70
3F32SSE	3L4' T8/ELIG	88
3F32SSH	3L4' T8/ELIG HIGH LMN	112
3F32SSL	3L4' T8/ELIG LOW POWER	76
3F32SSM	3L4' T8/EEMAG	107
4F32SSE	4L4' T8/ELIG	112
4F32SSH	4L4' T8/ELIG HIGH LMN	156
4F32SSL	4L4' T8/ELIG LOW PWR	98
4F32SSM	4L4' T8/EEMAG	140
5F32SSE	5L4' T8/ELIG	148
5F32SSH	5L4' T8/ELIG HIGH LMN	190
6F32SSE	6L4' T8/ELIG	174
8F32SSH	8L4' T8/ELIG HIGH LMN	312
Five Foot T8 / T12 Systems		
1F60HSM	1L5' HO/STD/EEMAG	90
1F60HSE	1L5' HO/STD/ELIG	70
1F60SSM	1L5'/STD/EEMAG	73
1F60TSM	1L5' T10HO/STD/EEMAG	135
2F40HSE	2L5' HO/STD/ELIG	123
2F40TSE	2L5'T8/ELIG	68
2F60HSM	2L5' HO/STD/EEMAG	178
2F60SSM	2L5'/STD/EEMAG	122
3F40TSE	3L5'T8/ELIG	106
Six Foot T12 & T12HO Systems		
1F72HSE	1L6' T8HO/ELIG	80
1F72HSS	1L6' F72HO/STD/STD	113
1F72SSM	1L6' STD/EEMAG	80
1F72SSS	1L6' STD/STD	95
2F72HSE	2L6'T8 HO/ELIG	160
2F72HSM	2L6' F72HO/STD/EEMAG	193
2F72HSS	2L6' F72HO/STD	195
2F72SSM	2L6' STD/EEMAG	135
2F72SSS	2L6' STD/STD	173

Device Code	Device Description	Rated Watts
Eight Foot T12HO Systems		
1F96HES	1L8' HO/EE/STD	125
1F96HSS	1L8' HO/STD/STD	135
2F96HEE	2L8' HO/EE/ELIG	170
2F96HEM	2L8' HO/EE/EEMAG	207
2F96HES	2L8' HO/EE/STD	227
2F96HSE	2L8' HO/STD/ELIG	195
2F96HSM	2L8' HO/STD/EEMAG	237
2F96HSS	2L8' HO/STD/STD	257
3F96HES	3L8' HO/EE/STD	352
3F96HSS	3L8' HO/STD/STD	392
4F96HEE	4L8' HO/EE/ELIG	340
4F96HEM	4L8' HO/EE/EEMAG	414
4F96HES	4L8' HO/EE/STD	454
4F96HSE	4L8' HO/STD/ELIG	390
4F96HSM	4L8' HO/STD/EEMAG	474
4F96HSS	4L8' HO/STD/STD	514
Eight Foot T12VHO Systems		
1F96VES	1L8' VHO/EE/STD	200
1F96VSS	1L8' VHO/STD/STD	230
2F96VES	2L8' VHO/EE/STD	390
2F96VSS	2L8' VHO/STD/STD	450
3F96VES	3L8' VHO/EE/STD	590
3F96VSS	3L8' VHO/STD/STD	680
4F96VES	4L8' VHO/EE/STD	780
4F96VSS	4L8' VHO/STD/STD	900
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
Eight Foot T12 Systems		
1F96SEE	1L8' EE/ELIG	60
1F96SES	1L8' EE/STD	83
1F96SSE	1L8' STD/ELIG	70
1F96SSS	1L8' STD/STD	100
2F96SEE	2L8' EE/ELIG	109
2F96SEM	2L8' EE/EEMAG	123
2F96SES	2L8' EE/STD	138
2F96SSE	2L8' STD/ELIG	134
2F96SSM	2L8' STD/EEMAG	158
2F96SSS	2L8' STD/STD	173

3F96SES	3L8' EE/STD	221
Device Code	**Device Description**	**Rated Watts**
Eight Foot T12 Systems (cont.)		
3F96SSS	3L8' STD/STD	273
4F96SEE	4L8' EE/ELIG	218
4F96SEM	4L8' EE/EEMAG	246

Device Code	**Device Description**	**Rated Watts**
Eight Foot T12 Systems (cont.)		
4F96SES	4L8' EE/STD	276
4F96SSE	4L8' STD/ELIG	268
4F96SSM	4L8' STD/EEMAG	316
4F96SSS	4L8' STD/STD	346

Table 58: MassSAVE Retrofit Proposed Lighting Wattage Tables

2012 MassSAVE C&I Lighting Rated Wattage Tables developed by Lighting Worksheet Team

Device Code	Device Description	Rated Watts
LED Exit Signs		
1E0002	2.0 WATT LED	2
1E0003	3.0 WATT LED	3
1E0005	5.0 WLED	5
1E0005C	0.5 WATT LEC	0.5
1E0008	8.0 WLED	8
1E0015	1.5 WATT LED	1.5
1E0105	10.5 WATT LED	10.5
Compact Fluorescents (CFL's)		
2C0007S	2/7W COMPACT HW	18
1C0005S	5W COMPACT HW	7
1C0007S	7W COMPACT HW	9
1C0009S	9W COMPACT HW	11
1C0011S	11W COMPACT HW	13
1C0013S	13W COMPACT HW	15
1C0018E	18W COMPACT HW ELIG	20
1C0018S	18W COMPACT HW	20
1C0022S	22W COMPACT HW	24
1C0023E	1/23W COMPACT HW ELIG	25
1C0026E	26W COMPACT HW ELIG	28
1C0026S	26W COMPACT HW	28
1C0028S	28W COMPACT HW	30
1C0032E	32W COMPACT HW ELIG	34
1C0032S	32W CIRCLINE HW	34
1C0042E	1/42W COMPACT HW ELIG	48
1C0044S	44W CIRCLINE HW	46
1C0057E	1/57W COMPACT HW ELIG	65
1C2232S	22/32W CIRCLINE HW	58
1C2D10E	10W 2D COMPACT HW ELIG	12
1C2D16E	16W 2D COMPACT HW ELIG	18
1C2D21E	21W 2D COMPACT HW ELIG	22
1C2D28E	28W 2D COMPACT HW ELIG	28
1C2D38E	38W 2D COMP.HW ELIG	36
1C3240S	32/40W CIRCLINE HW	80
2C0005S	2/5W COMPACT HW	14
2C0009S	2/9W COMPACT HW	22
2C0011S	2/11W COMPACT HW	26
2C0013E	2/13W COMPACT HW ELIG	28
2C0013S	2/13W COMPACT HW	30
2C0018E	2/18W COMP. HW ELIG	40
2C0026E	2/26W COMP. HW ELIG	54
2C0032E	2/32W COMPACT HW ELIG	68

Device Code	Device Description	Rated Watts
Compact Fluorescents (CFL's) (cont.)		
2C0042E	2/42W COMPACT HW ELIG	100
3C0009S	3/9W COMPACT HW	33
3C0013S	3/13W COMPACT HW	45
3C0018E	3/18W COMPACT HW ELIG	60
3C0026E	3/26W COMPACT HW ELIG	82
3C0032E	3/32W COMPACT HW ELIG	114
3C0042E	3/42W COMPACT HW ELIG	141
4C0018E	4/18W COMPACT HW ELIG	80
4C0026E	4/26W COMPACT HW ELIG	108
4C0032E	4/32W COMPACT HW ELIG	152
4C0042E	4/42W COMPACT HW ELIG	188
6C0026E	6/26W COMPACT HW ELIG	162
6C0032E	6/32W COMPACT HW ELIG	228
6C0042E	6/42W COMPACT HW ELIG	282
8C0026E	8/26W COMPACT HW ELIG	216
8C0032E	8/32W COMPACT HW ELIG	304
8C0042E	8/42W COMPACT HW ELIG	376
T5 Systems		
1F14SSE	1L2' 14W T5/ELIG	16
2F14SSE	2L2' 14W T5/ELIG	32
3F14SSE	3L2' 14W T5/ELIG	50
4F14SSE	4L2' 14W T5/ELIG	68
1F24HSE	1L2' 24W T5HO/ELIG	29
2F24HSE	2L2' 24W T5HO/ELIG	52
3F24HSE	3L2' 24W T5HO/ELIG	80
1F21SSE	1L3' 21W T5/ELIG	24
2F21SSE	2L3' 21W T5/ELIG	47
1F39HSE	1L3' 39W T5HO/ELIG	42
2F39HSE	2L3' 39W T5HO/ELIG	85
1F28SSE	1L4' 28W T5/ELIG	32
2F28SSE	2L4' 28W T5/ELIG	63
3F28SSE	3L4' 28W T5/ELIG	95
4F28SSE	4L4' 28W T5/ELIG	126
6F28SSE	6L4' 28W T5/ELIG	189
1F47HSE	1L4' 47W T5HO/ELIG	53
2F47HSE	2L4' 47W T5HO/ELIG	103
3F47HSE	3L4' 47W T5HO/ELIG	157
4F47HSE	4L4' 47W T5HO/ELIG	200
5F47HSE	5L4' 47W T5HO/ELIG	260
6F47HSE	6L4' 47W T5HO/ELIG	303
1F50HSE	1L4' 50W T5HO/ELIG	58

Device Code	Device Description	Rated Watts
T5 Systems (cont.)		
2F50HSE	2L4' 50W T5HO/ELIG	110
3F50HSE	3L4' 50W T5HO/ELIG	168
4F50HSE	4L4' 50W T5HO/ELIG	215
5F50HSE	5L4' 50W T5HO/ELIG	278
6F50HSE	6L4' 50W T5HO/ELIG	325
1F54HSE	1L4' 54W T5HO/ELIG	59
2F54HSE	2L4' 54W T5HO/ELIG	117
3F54HSE	3L4' 54W T5HO/ELIG	177
4F54HSE	4L4' 54W T5HO/ELIG	234
5F54HSE	5L4' 54W T5HO/ELIG	294
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
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

Device Code	Device Description	Rated Watts
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
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

Device Code	Device Description	Rated Watts
Four Foot T8 High Efficient / Reduce Wattage Systems (cont.)		
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
6F32EEH	6L4' 32W T8EE/ELEE HIGH PWR	218
6F32EEE	6L4' 32W T8EE/ELEE	168
6F32EEL	6L4' 32W T8EE/ELEE LOW PWR	146
Eight Foot T8 Systems		
1F59SSE	1L8' T8/ELIG	60
1F80SSE	1L8' T8 HO/ELIG	85
2F59SSE	2L8' T8/ELIG	109
2F59SSL	2L8' T8/ELIG LOW PWR	100
2F80SSE	2L8' T8 HO/ELIG	160
LED Lighting Fixtures		
1L002	2 WATT LED	2
1L003	3 WATT LED	3
1L004	4 WATT LED	04
1L005	5 WATT LED	05
1L006	6 WATT LED	06
1L007	7 WATT LED	07
1L008	8 WATT LED	08
1L009	9 WATT LED	09

Device Code	Device Description	Rated Watts
LED Lighting Fixtures (cont.)		
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
1L055	55 WATT LED	55
1L060	60 WATT LED	60
1L070	70 WATT LED	70
1L073	73 WATT LED	73

Device Code	Device Description	Rated Watts
LED Lighting Fixtures (cont.)		
1L075	75 WATT LED	75
1L080	90 WATT LED	90
1L085	85 WATT LED	85
1L090	90 WATT LED	90
1L095	95 WATT LED	95
1L100	100 WATT LED	100
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
1L135	135 WATT LED	135
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
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
1L190	190 WATT LED	190
1L200	200 WATT LED	200
Device Code	**Device Description**	**Rated Watts**
LED Lighting Fixtures (cont.)		
1L210	210 WATT LED	210
1L220	220 WATT LED	220
1L240	240 WATT LED	240
Electronic Metal Halide Lamps		
1M0150E	150W METAL HALIDE EB	160
1M0200E	200W METAL HALIDE EB	215
1M0250E	250W METAL HALIDE EB	270
1M0320E	320W METAL HALIDE EB	345
1M0350E	350W METAL HALIDE EB	375
1M0400E	400W METAL HALIDE EB	430
1M0450E	400W METAL HALIDE EB	480
MH Track Lighting		
1M0020E	20W MH SPOT	25
1M0025E	25W MH SPOT	25
1M0035E	35W MH SPOT	44
1M0039E	39W MH SPOT	47
1M0050E	50W MH SPOT	60
1M0070E	70W MH SPOT	80
1M0100E	100W MH SPOT	111
1M0150E	150W MH SPOT	162

Table 59: Default Effective Lighting Hours by Building Type[750]

Building Type	Annual Operating Hours
Assembly	2857 (one shift)
Automobile	4056 (retail)
Big Box	4057 (retail)
Community College	3255
Dormitory	3,056
Fast Food	5110
Full Service Restaurant	5110
Grocery	6074
Heavy Industrial	4,057
Hospital	8036
Hotel	8583
Large Refrigerated Space	2602 (warehouse)
Large Office	3610
Light Industrial	4,730 (two shift)
Motel	8583
Multi Story Retail	4089
Multifamily high-rise	7665 (Common Area)
Multifamily low-rise	7665 (Common Area)
Other	3951
Religious	1955
K-12 Schools	2596
Small Office	3610
Small Retail	4089
University	3255
Warehouse	3759

Table 60: Cooling and Heating Equivalent Full Load Hours

Building (or Space) Type	Cooling Full Load Hours ($EFLH_{cool}$)	Heating Full Load Hours ($EFLH_{heat}$)
Average – CLC	1,172	530
Average – NSTAR	1,172	N/A
Average – National Grid	989	881
Average – Unitil	719	1,398
Average – WMECO	755	1,329
Site Specific - NSTAR	800, 1000-6000 at 1000 hour increments	N/A

- Average Cooling EFLHs from the 2010 NEEP HVAC Loadshape study.[751]
- Average Heating EFLHs derived from 2010 NEEP HVAC Loadshape study[752] and the Connecticut Program Savings Document for 2011 Program Year.[753]

[750] Lighting hours developed from Massachusetts Common Assumptions and New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (2010). Values are provided for use when site-specific hours are not available.
[751] KEMA (2011). C&I Unitary AC LoadShape Project – Final Report. Prepared for the Regional Evaluation, Measurement & Verification Forum.
[752] Ibid.

Table 61: EPACT 1992 Baseline Motor Efficiencies[754]

Motor Horsepower	Open Drip Proof			Totally Enclosed Fan Cooled		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1	80.0	82.5	N/A	80.0	82.5	75.5
1.5	84.0	84.0	82.5	85.5	84.0	82.5
2	85.5	84.0	84.0	86.5	84.0	84.0
3	86.5	86.5	84.0	87.5	87.5	85.5
5	87.5	87.5	85.5	87.5	87.5	87.5
7.5	88.5	88.5	87.5	89.5	89.5	88.5
10	90.2	89.5	88.5	89.5	89.5	89.5
15	90.2	91.0	89.5	90.2	91.0	90.2
20	91.0	91.0	90.2	90.2	91.0	90.2
25	91.7	91.7	91.0	91.7	92.4	91.0
30	92.4	92.4	91.0	91.7	92.4	91.0
40	93.0	93.0	91.7	93.0	93.0	91.7
50	93.0	93.0	92.4	93.0	93.0	92.4
60	93.6	93.6	93.0	93.6	93.6	93.0
75	93.6	94.1	93.0	93.6	94.1	93.0
100	94.1	94.1	93.0	94.1	94.5	93.6
125	94.1	94.5	93.6	94.1	94.5	94.5
150	94.5	95.0	93.6	95.0	95.0	94.5
200	94.5	95.0	94.5	95.0	95.0	95.0

[753] United Illuminating Company, Connecticut Light & Power Company (2010). *UI and CL&P Program Savings Documentation for 2011 Program Year.*
[754] Energy Policy Act of 1992

Table 62: Minimum Premium Efficiency Motors Compliance Efficiencies[755]

Motor Horsepower	Open Drip Proof			Totally Enclosed Fan Cooled		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1	82.5	85.5	N/A	82.5	85.5	77.0
1.5	86.5	86.5	84	87.5	86.5	84
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91	88.5	91	91.7	89.5
10	91.7	91.7	89.5	91	91.7	90.2
15	97.7	93	90.2	91.7	92.4	91
20	92.4	93	91	91.7	93	91
25	93	93.6	91.7	93	93.6	91.7
30	93.6	94.1	91.7	93	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93	94.1	94.5	93
60	94.5	95	93.6	94.5	95	93.6
75	94.5	95	93.6	94.5	95.4	93.6
100	95	95.4	93.6	95	95.4	94.1
125	95	95.4	94.1	95	95.4	95
150	95.4	95.8	94.1	95.8	95.8	95
200	95.4	95.8	95	95.8	96.2	95.4

[755] NEMA Premium MG1-2006 Table 12-12

Appendix B: Net to Gross Impact Factors

Residential Electric Efficiency Measures					
Measure	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
Residential New Construction & Major Renovation					
ES Homes - Cooling	All	0%	0%	0%	100%
ES Homes - Heating	All	0%	0%	0%	100%
ES Homes - Water Heating	All	0%	0%	0%	100%
Indoor Fixture[756]	All	23%	0%	0%	77%
LED Fixture[757]	All	23%	0%	0%	77%
Refrigerators	All	86%	0%	0%	14%
Screw-in Bulbs[758]	All	23%	0%	0%	77%
Residential Cooling & Heating Equipment					
CoolSmart AC (SEER >= 15 / EER >= 12.5)	All	15%	0%	0%	85%
CoolSmart AC (SEER >= 15 / EER >= 13)	All	15%	0%	0%	85%
CoolSmart AC (SEER 14.5 / EER 12)	All	15%	0%	0%	85%
CoolSmart AC (SEER 16 / EER 13)	All	15%	0%	0%	85%
CoolSmart AC Digital Check-up/Tune-up	All	15%	0%	0%	85%
CoolSmart AC QIV	All	15%	0%	0%	85%
CoolSmart HP (SEER >= 15/ EER 12.5/ HSPF 8.5)	All	15%	0%	0%	85%
CoolSmart HP (SEER 14.5 / EER 12/ HSPF 8.2)	All	15%	0%	0%	85%
CoolSmart HP Digital Check-up/Tune-up	All	15%	0%	0%	85%
CoolSmart HP MS (SEER 14.5 / EER 12.0 / HSPF 8.2)	All	15%	0%	0%	85%
CoolSmart HP MS (SEER 19 / EER 12.8 / HSPF 10.0)	All	15%	0%	0%	85%
CoolSmart HP MS (SEER 23 / EER 13 / HSPF 10.6)	All	15%	0%	0%	85%
CoolSmart HP QIV	All	15%	0%	0%	85%
CoolSmart Warm Air Furnace ECM	All	35%	15%	0%	80%
Down Size 1/2 Ton	All	15%	0%	0%	85%
Duct Sealing	All	15%	0%	0%	85%
Early Replacement of AC/HP Equipment	All	15%	0%	0%	85%
Energy Star QI	All	15%	0%	0%	85%
Energy Star QI w/ Duct modifications	All	15%	0%	0%	85%
Right Sizing	All	15%	0%	0%	85%
MassSAVE					
Air Sealing, Electric	All	8%	8%	28%	129%
Air Sealing, Oil	All	8%	8%	28%	129%
Air Sealing, Other FF	All	8%	8%	28%	129%
Boiler Reset Controls	All	0%	0%	0%	100%

[756] Based on the 2012 IECC requirement that 75% of lighting be high efficacy and the fact that the MA RNC Baseline study looking at homes built under the 2009 IECC found only 23% of homes had high efficacy lighting (where the requirement was 50%); free-ridership is estimated to escalate over the three years from 23% in 2013, to 33% in 2014, and 40% in 2015.
[757] Ibid.
[758] Ibid.

DHW ISMs, Electric	All	2%	0%	0%	98%
DHW ISMs, Oil	All	2%	0%	0%	98%
DHW ISMs, Other FF	All	2%	0%	0%	98%
Duct Insulation, Electric	All	25%	20%	28%	123%
Duct Insulation, Oil	All	25%	20%	28%	123%
Duct Insulation, Other FF	All	25%	20%	28%	123%
Duct Seal, Electric	All	8%	8%	28%	129%
Duct Seal, Oil	All	8%	8%	28%	129%
Duct Seal, Other FF	All	8%	8%	28%	129%
ES Window, Electric	All	0%	0%	0%	100%
ES Window, Oil	All	0%	0%	0%	100%
ES Window, Other FF	All	0%	0%	0%	100%
Heating System Replacement, Oil	All	28%	0%	0%	72%
Heating System Replacement, Other FF	All	28%	0%	0%	72%
Indirect Water Heater, Oil	All	25%	0%	0%	75%
Indirect Water Heater, Other FF	All	25%	0%	0%	75%
Insulation, Electric	All	25%	20%	28%	123%
Insulation, Oil	All	25%	20%	28%	123%
Insulation, Other FF	All	25%	20%	28%	123%
Refrigerator (ES Value)	All	14%	0%	0%	86%
Refrigerator (Retirement Value)	All	14%	0%	0%	86%
Screw-in Bulbs	All	24%	2.5%	0%	78.5%
Screw-in Bulbs (piggyback)	All	24%	2.5%	0%	78.5%
Smart Strips	All	0%	0%	0%	100%
Thermostats, Electric	All	11%	0%	0%	89%
Thermostats, Oil	All	11%	0%	0%	89%
Thermostats, Other FF	All	11%	0%	0%	89%
Torchiere	All	6%	3%	0%	97%
Multi-Family Retrofit					
Air Sealing	All	19%	0%	0%	81%
Insulation	All	19%	0%	0%	81%
Showerheads	All	15%	0%	0%	85%
Aerators	All	15%	0%	0%	85%
DHW Tank/Pipe Wrap	All	15%	0%	0%	85%
Fixtures	All	18%	0%	0%	82%
Screw-in Bulbs	All	18%	0%	0%	82%
Heat Pump Tune-Up	All	3%	0%	0%	97%
Programmable Thermostats	All	24%	0%	0%	76%
Refrigerator	All	3%	0%	0%	97%
Room AC	All	35%	0%	0%	65%
Smart Strips	All	0%	0%	0%	100%
Behavior/Feedback Program					
All Groups	National Grid, NSTAR	0%	0%	0%	100%

ENERGY STAR Lighting					
Indoor Fixture	All	8%	4%	0%	96%
LED Fixture	All	0%	0%	0%	100%
LED Lamp	All	0%	0%	0%	100%
Outdoor Fixture	All	12%	7%	0%	95%
Screw-in Bulbs	All	57%	0%	0%	43%
Screw-in Bulbs (Hard to Reach)	All	40%	0%	0%	60%
Screw-in Bulbs (School Fundraiser)	All	0%	0%	0%	100%
Screw-in Bulbs (Specialty bulbs)	All	40%	0%	0%	60%
Screw-in Bulbs (EISA Exempt)	All	40%	0%	0%	60%
Torchiere	All	6%	3%	0%	97%
ENERGY STAR Appliances					
Dehumidifiers (ES Value)	All	0%	0%	0%	100%
Dehumidifiers (Retirement Value)	All	0%	0%	0%	100%
Energy Star Freezer Rebate	All	35%	0%	0%	65%
Top Ten Freezer Rebate	All	25%	0%	0%	75%
Energy Star Television	All	50%	0%	0%	50%
Top Ten Television	All	25%	0%	0%	75%
Energy Star Desktop Computers	All	35%	0%	0%	65%
Top Ten Desktop Computers	All	25%	0%	0%	75%
Pool Pumps	All	0%	0%	0%	100%
Refrigerator Recycling Primary	All	45%	0%	0%	55%
Refrigerator Recycling Secondary Replaced	All	27%	0%	0%	73%
Refrigerator Recycling Secondary Not Replaced	All	29%	0%	0%	71%
Refrigerator Recycling (combined)	All	31%	0%	0%	69%
Freezer Recycling	All	41%	0%	0%	59%
Energy Star Refrigerator Rebate	All	35%	0%	0%	65%
Top Ten Refrigerator Rebate	All	25%	0%	0%	75%
Room Air Cleaner	All	0%	0%	0%	100%
Room AC 10.8 EER	All	36%	0%	0%	64%
Smart Strips	All	0%	0%	0%	100%
Low-Income Residential New Construction					
ES Homes - Cooling	All	0%	0%	0%	100%
ES Homes - Heating	All	0%	0%	0%	100%
ES Homes - Water Heating	All	0%	0%	0%	100%
Indoor Fixture[759]	All	23%	0%	0%	77%
LED Fixture[760]	All	23%	0%	0%	77%
Refrigerators	All	86%	0%	0%	14%
Screw-in Bulbs[761]	All	23%	0%	0%	77%

[759] Based on the 2012 IECC requirement that 75% of lighting be high efficacy and the fact that the MA RNC Baseline study looking at homes built under the 2009 IECC found only 23% of homes had high efficacy lighting (where the requirement was 50%); free-ridership is estimated to escalate over the three years from 23% in 2013, to 33% in 2014, and 40% in 2015.
[760] Ibid.
[761] Ibid.

Low-Income 1-4 Family Retrofit					
Appliance Removal	All	0%	0%	0%	100%
Baseload	All	0%	0%	0%	100%
Boiler Reset Controls	All	0%	0%	0%	100%
CFLs	All	0%	0%	0%	100%
LED	All	0%	0%	0%	100%
CFL Fixture	All	0%	0%	0%	100%
Dehumidifiers (ES Value)	All	0%	0%	0%	100%
Dehumidifiers (Retirement Value)	All	0%	0%	0%	100%
DHW Measures (Electric)	All	0%	0%	0%	100%
DHW Measures (Gas/Other)	All	0%	0%	0%	100%
DHW Measures (Oil)	All	0%	0%	0%	100%
Electric Weatherization	All	0%	0%	0%	100%
Freezer Replacement	All	0%	0%	0%	100%
Fuel Switching	All	0%	0%	0%	100%
Heating System Replacement (Oil)	All	0%	0%	0%	100%
Oil Weatherization	All	0%	0%	0%	100%
Programmable Thermostats (Oil)	All	0%	0%	0%	100%
Refrigerator Replacement	All	0%	0%	0%	100%
Smart Strips	All	0%	0%	0%	100%
Solar DHW	All	0%	0%	0%	100%
Torchieres	All	0%	0%	0%	100%
Waterbed	All	0%	0%	0%	100%
Window AC Replacement	All	0%	0%	0%	100%
Low-Income Multi-Family Retrofit					
Baseload	All	0%	0%	0%	100%
CFL Fixtures	All	0%	0%	0%	100%
CFLs	All	0%	0%	0%	100%
DHW Measures	All	0%	0%	0%	100%
Electric Weatherization	All	0%	0%	0%	100%
Freezer Replacement	All	0%	0%	0%	100%
Heating System Replacement (Oil)	All	0%	0%	0%	100%
Refrigerator (ES Value)	All	0%	0%	0%	100%
Refrigerator (Retirement Value)	All	0%	0%	0%	100%
Smart Strips	All	0%	0%	0%	100%
Torchieres	All	0%	0%	0%	100%
Waterbed	All	0%	0%	0%	100%
Window AC Replacement	All	0%	0%	0%	100%

EVALUATIONS

Unless otherwise stated below, all PA's use Massachusetts common assumptions for all residential electric measure free-ridership and spillover values.

All PAs base the NTG factors for the ENERGY STAR Lighting Screw-In Bulbs and Screw-In Bulbs (Specialty bulbs) measures on the Massachusetts ENERGY STAR® Lighting Program: 2010 Annual Report.[762]

All PAs base the NTG factors for the Refrigerator and Freezer Recycling measures on the Massachusetts Appliance Turn-in Program Evaluation Integrated Report Findings Report.[763]

All PAs base the NTG factors for the MassSAVE Screw-In Bulbs, Screw-In Bulbs (piggyback), Refrigerator, Air Sealing, Insulation, Duct Seal and Duct Insulation on the Massachusetts 2011 Residential Retrofit and Low Income Net to Gross Evaluation[764]. NTG factors for Screw-In Bulbs and Screw-In Bulbs (piggyback) are also based on this study but modified by agreement with EEAC consultants of 7-2-12, to account for the potential for participants who would have bought CFLs outside of the HES program but through the Upstream Lighting program.

All PAs base the NTG factors for the MassSAVE Thermostats, Heating System Replacement and Indirect Water Heater measures on the 2010 Net-to-Gross Findings: Home Energy Assessment study.[765]

All PAs base the NTG factors for the Residential New Construction program appliances and lighting measures on the Massachusetts Baseline Study.[766]

[762] NMR Group, Inc (2011). *Massachusetts ENERGY STAR® Lighting Program: 2010 Annual Report.* Prepared for the Electric Program Administrators of Massachusetts; June 13, 2011.
[763] NMR Group, Inc (2011). *Massachusetts Appliance Turn-in Program Evaluation Integrated Report Findings.* Prepared for the Electric Program Administrators of Massachusetts.
[764] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit and Low Income Net-to-Gross Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts
[765] The Cadmus Group (2011). *2010 Net-to-Gross Findings: Home Energy Assessment.* Prepared for the Electric and Gas Program Administrators of Massachusetts
[766] NMR Group, Inc., KEMA Inc., Dorothy Conant (2012). Massachusetts Baseline Study of Single-family Residential New Construction July 17, 2012.

Commercial Electric Efficiency Measures					
Measure	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
C&I New Construction and Major Renovation					
Advanced Lighting Design (Performance Lighting)	National Grid	33%	29%	0%	96%
Advanced Lighting Design (Performance Lighting)	NSTAR	12%	2%	0%	90%
Advanced Lighting Design (Performance Lighting)	Unitil	19.9%	8.8%	0%	88.9%
Advanced Lighting Design (Performance Lighting)	WMECo	20%	9%	0%	89%
Advanced Lighting Design (Performance Lighting)	CLC	20%	9%	0%	89%
Lighting Controls	National Grid	33%	16%	0%	83%
Lighting Controls	NSTAR	12%	2%	0%	90%
Lighting Controls	Unitil	19.9%	8.8%	0%	88.9%
Lighting Controls	WMECo	20%	9%	0%	89%
Lighting Controls	CLC	20%	9%	0%	89%
Lighting Systems	National Grid	33%	16%	0%	83%
Lighting Systems	NSTAR	12%	2%	0%	90%
Lighting Systems	Unitil	19.9%	8.8%	0%	88.9%
Lighting Systems	WMECo	20%	9%	0%	89%
Lighting Systems	CLC	20%	9%	0%	89%
Upstream Lighting T8s/T5s	National Grid	19%	0%	0%	81%
Upstream Lighting T8s/T5s	NSTAR	19%	0%	0%	81%
Upstream Lighting T8s/T5s	Unitil	19%	0%	0%	81%
Upstream Lighting T8s/T5s	WMECo	19%	0%	0%	81%
Upstream Lighting T8s/T5s	CLC	18%	0%	0%	82%
Upstream Lighting LEDs	All	3%	0%	0%	97%
Demand Control Ventilation (DCV)	National Grid	26%	2%	0%	75%
Demand Control Ventilation (DCV)	NSTAR	21%	14%	0%	94%
Demand Control Ventilation (DCV)	Unitil	30.6%	0%	3.6%	73%
Demand Control Ventilation (DCV)	WMECo	30%	1%	0%	71%
Demand Control Ventilation (DCV)	CLC	22%	12%	0%	90%
Dual Enthalpy Economizer Controls (DEEC)	National Grid	26%	2%	0%	75%
Dual Enthalpy Economizer Controls (DEEC)	NSTAR	21%	14%	0%	94%
Dual Enthalpy Economizer Controls (DEEC)	Unitil	30.6%	0%	3.6%	73%
Dual Enthalpy Economizer Controls (DEEC)	WMECo	30%	1%	0%	71%
Dual Enthalpy Economizer Controls (DEEC)	CLC	22%	12%	0%	90%
ECM Fan Motors	National Grid	26%	2%	0%	75%
ECM Fan Motors	NSTAR	21%	14%	0%	94%
ECM Fan Motors	Unitil	30.6%	0%	3.6%	73%
ECM Fan Motors	WMECo	30%	1%	0%	71%
ECM Fan Motors	CLC	22%	12%	0%	90%
Energy Management System (EMS)	CLC	22%	12%	0%	90%
HE Chiller	National Grid	26%	2%	0%	75%
HE Chiller	NSTAR	21%	14%	0%	94%
HE Chiller	Unitil	30.6%	0%	3.6%	73%
HE Chiller	WMECo	30%	1%	0%	71%
HE Chiller	CLC	22%	12%	0%	90%
Single-Package and SS Heat Pump Systems	National Grid	29%	2%	0%	73%
Single-Package and SS Heat Pump Systems	NSTAR	21%	14%	0%	94%

Single-Package and SS Heat Pump Systems	Unitil	30.6%	0%	3.6%	73%
Single-Package and SS Heat Pump Systems	WMECo	30%	1%	0%	71%
Single-Package and SS Heat Pump Systems	CLC	22%	12%	0%	90%
Single-Package and SS Unitary air conditioners	National Grid	29%	2%	0%	73%
Single-Package and SS Unitary air conditioners	NSTAR	21%	14%	0%	94%
Single-Package and SS Unitary air conditioners	Unitil	30.6%	0%	3.6%	73%
Single-Package and SS Unitary air conditioners	WMECo	30%	1%	0%	71%
Single-Package and SS Unitary air conditioners	CLC	22%	12%	0%	90%
HE Air Compressor	National Grid	32%	0%	2%	70%
HE Air Compressor	NSTAR	37%	10%	1%	74%
HE Air Compressor	Unitil	30.6%	0%	3.6%	73%
HE Air Compressor	WMECo	34%	4%	2%	72%
HE Air Compressor	CLC	34%	4%	2%	72%
Refrigerated Air Dryers	National Grid	32%	0%	2%	70%
Refrigerated Air Dryers	NSTAR	37%	10%	1%	74%
Refrigerated Air Dryers	Unitil	30.6%	0%	3.6%	73%
Refrigerated Air Dryers	WMECo	34%	4%	2%	72%
Refrigerated Air Dryers	CLC	34%	4%	2%	72%
Variable Frequency Drives	National Grid	25%	0%	8%	82%
Variable Frequency Drives	NSTAR	23%	2%	8%	86%
Variable Frequency Drives	Unitil	30.6%	0%	3.6%	73%
Variable Frequency Drives	WMECo	23%	1%	8%	86%
Variable Frequency Drives	CLC	23%	1%	8%	86%
Commercial Electric Ovens	All	0%	0%	0%	100%
Commercial Electric Steam Cooker	All	0%	0%	0%	100%
Commercial Electric Griddle	All	0%	0%	0%	100%
Custom	National Grid	16%	29%	0%	113%
Custom	Unitil	20.%	11.5%	0%	92.3%
Custom - Compressed Air	NSTAR	37%	10%	1%	74%
Custom – Compressed Air	WMECo	34%	4%	2%	72%
Custom - HVAC	NSTAR	21%	14%	0%	94%
Custom - HVAC	CLC	22%	12%	0%	90%
Custom – HVAC	WMECO	31%	1%	0%	71%
Custom - Lighting	NSTAR	12%	2%	0%	90%
Custom - Lighting	WMECo	20%	9%	0%	89%
Custom - Lighting	CLC	20%	0%	0%	80%
Custom - Motors	NSTAR	23%	2%	8%	86%
Custom – Motors	WMECO	23%	1%	8%	86%
Custom - Process	WMECo	7%	0%	0%	93%
Custom - Process Equipment	NSTAR	10%	1%	0%	91%
Custom - Refrigeration	NSTAR	13%	35%	0%	122%
Custom - Refrigeration	CLC	13%	35%	0%	122%
Custom – Refrigeration	WMECO	13%	35%	0%	122%
Custom – Food Services (Ovens, Cookers, etc)	NSTAR	0%	0%	0%	100%
Custom – Food Services (Ovens, Cookers, etc)	WMECO	0%	0%	0%	100%
C&I Large Retrofit					
Lighting Controls	National Grid	17%	3%	0%	86%
Lighting Controls	NSTAR	18%	17%	0%	99%

Lighting Controls	Unitil	16.9%	8.4%	0%	91.5%
Lighting Controls	WMECo	20%	5%	0%	85%
Lighting Controls	CLC	17%	5%	0%	88%
Lighting Systems	National Grid	17%	3%	0%	86%
Lighting Systems	NSTAR	18%	17%	0%	99%
Lighting Systems	Unitil	16.9%	8.4%	0%	91.5%
Lighting Systems	WMECo	20%	5%	0%	85%
Lighting Systems	CLC	17%	8%	0%	91%
Vending Machine and Cooler Controls (Lighting)	NSTAR	18%	17%	0%	99%
Energy Management System (EMS)	National Grid	11%	4%	0%	93%
Energy Management System (EMS)	NSTAR	13%	6%	0%	93%
Energy Management System (EMS)	Unitil	13.4%	6.4%	0%	93%
Energy Management System (EMS)	WMECo	13%	6%	0%	93%
Energy Management System (EMS)	CLC	13%	6%	0%	93%
Hotel Occupancy Sensors	National Grid	11%	4%	0%	93%
Hotel Occupancy Sensors	NSTAR	13%	6%	0%	93%
Hotel Occupancy Sensors	Unitil	13.4%	6.4%	0%	93%
Hotel Occupancy Sensors	WMECo	13%	6%	0%	93%
Hotel Occupancy Sensors	CLC	17%	5%	0%	88%
LEDs in Freezers/Coolers	CLC	17%	5%	0%	88%
Vending Machine and Cooler Controls	National Grid	11%	4%	0%	93%
Vending Machine and Cooler Controls	Unitil	13.4%	6.4%	0%	93%
Vending Machine and Cooler Controls	WMECo	13%	6%	0%	93%
Vending Machine and Cooler Controls (Refrigeration)	NSTAR	14%	56%	0%	142%
Vending Misers	CLC	9%	36%	0%	127%
HE Air Compressor	National Grid	23%	0%	2%	78%
HE Air Compressor	NSTAR	7%	0%	2%	95%
HE Air Compressor	Unitil	7%	0%	1.5%	94.5%
HE Air Compressor	WMECo	7%	0%	1%	94%
HE Air Compressor	CLC	7%	0%	2%	95%
Variable Frequency Drives	National Grid	10%	7%	8%	104%
Variable Frequency Drives	NSTAR	14%	7%	8%	101%
Variable Frequency Drives	Unitil	9.6%	6%	7.7%	104.1%
Variable Frequency Drives	WMECo	10%	6%	8%	104%
Variable Frequency Drives	CLC	10%	6%	8%	104%
Custom	National Grid	14%	8%	1%	95%
Custom	Unitil	15.7%	9.1%	0.7%	94.1%
Custom - Compressed Air	NSTAR	7%	0%	2%	95%
Custom – Compressed Air	WMECO	7%	0%	1%	94%
Custom - HVAC	NSTAR	13%	6%	0%	93%
Custom - HVAC	CLC	13%	6%	0%	93%
Custom – HVAC	WMECO	13%	6%	0%	93%
Custom - Lighting	NSTAR	18%	17%	0%	99%
Custom - Lighting	WMECo	20%	5%	0%	85%
Custom - Lighting	CLC	17%	8%	0%	91%
Custom – Motors	NSTAR	14%	7%	8%	101%
Custom – Motors	WMECO	10%	6%	8%	104%
Custom - Process	NSTAR	26%	11%	0%	85%

Custom – Process	WMECO	26%	11%	0%	85%
Custom – Refrigeration	NSTAR	14%	56%	0%	142%
Custom – Refrigeration	CLC	9%	36%	0%	127%
Custom – Refrigeration	WMECO	9%	36%	0%	127%
Custom – CHP	NSTAR	7%	16%	0%	109%
Custom – CHP	WMECO	7%	16%	0%	109%
C&I Small Retrofit					
Lighting Controls	National Grid	5%	1%	0%	96%
Lighting Controls	NSTAR	9%	4%	0%	95%
Lighting Controls	Unitil	4.8%	8.7%	0%	103.9%
Lighting Controls	WMECo	11%	1%	0%	90%
Lighting Controls	CLC	9%	6%	0%	97%
Lighting Systems	National Grid	5%	1%	0%	96%
Lighting Systems	NSTAR	9%	4%	0%	95%
Lighting Systems	Unitil	4.8%	8.7%	0%	103.9%
Lighting Systems	WMECo	11%	1%	0%	90%
Lighting Systems	CLC	9%	6%	0%	97%
Energy Management Systems (EMS)	CLC	7%	14%	0%	107%
Hotel Occupancy Sensors	CLC	7%	14%	0%	107%
Programmable Thermostats	National Grid	2%	2%	0%	100%
Programmable Thermostats	NSTAR	10%	27%	0%	117%
Programmable Thermostats	Unitil	6.8%	14%	0%	107.2%
Programmable Thermostats	CLC	7%	14%	0%	107%
Case Motor Replacement	National Grid	2%	2%	0%	100%
Case Motor Replacement	NSTAR	2%	13%	0%	111%
Case Motor Replacement	Unitil	2.2%	9.2%	0%	107%
Case Motor Replacement	WMECo	3%	2%	0%	99%
Case Motor Replacement	CLC	4%	0%	0%	96%
Cooler Night Covers	National Grid	2%	2%	0%	100%
Cooler Night Covers	NSTAR	2%	13%	0%	111%
Cooler Night Covers	Unitil	2.2%	9.2%	0%	107%
Cooler Night Covers	WMECo	3%	2%	0%	99%
Cooler Night Covers	CLC	4%	0%	0%	96%
Cooler/Freezer Door Heater Control	National Grid	2%	2%	0%	100%
Cooler/Freezer Door Heater Control	NSTAR	2%	13%	0%	111%
Cooler/Freezer Door Heater Control	Unitil	2.2%	9.2%	0%	107%
Cooler/Freezer Door Heater Control	WMECo	3%	2%	0%	99%
Cooler/Freezer Door Heater Control	CLC	4%	0%	0%	96%
Cooler/Freezer Evaporator Fan Controls	National Grid	2%	2%	0%	100%
Cooler/Freezer Evaporator Fan Controls	NSTAR	2%	13%	0%	111%
Cooler/Freezer Evaporator Fan Controls	Unitil	2.2%	9.2%	0%	107%
Cooler/Freezer Evaporator Fan Controls	WMECo	3%	2%	0%	99%
Cooler/Freezer Evaporator Fan Controls	CLC	4%	0%	0%	96%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	National Grid	2%	2%	0%	100%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	NSTAR	2%	13%	0%	111%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	Unitil	2.2%	9.2%	0%	107%

ECM for Evaporator Fans in Walk-in Coolers and Freezers	WMECo	3%	2%	0%	99%
ECM for Evaporator Fans in Walk-in Coolers and Freezers	CLC	4%	0%	0%	96%
Electronic Defrost Control	National Grid	2%	2%	0%	100%
Electronic Defrost Control	NSTAR	2%	13%	0%	111%
Electronic Defrost Control	Unitil	2.2%	9.2%	0%	107%
Electronic Defrost Control	WMECo	3%	2%	0%	99%
Electronic Defrost Control	CLC	4%	0%	0%	96%
LEDs in Freezers/Coolers	National Grid	5%	1%	0%	96%
LEDs in Freezers/Coolers	NSTAR	9%	4%	0%	95%
LEDs in Freezers/Coolers	Unitil	4.8%	8.7%	0%	103.9%
LEDs in Freezers/Coolers	WMECo	3%	2%	0%	99%
LEDs in Freezers/Coolers	CLC	9%	7%	0%	98%
Novelty Cooler Shutoff	National Grid	2%	2%	0%	100%
Novelty Cooler Shutoff	NSTAR	2%	13%	0%	111%
Novelty Cooler Shutoff	Unitil	2%	9%	0%	107%
Novelty Cooler Shutoff	WMECo	3%	2%	0%	99%
Novelty Cooler Shutoff	CLC	4%	0%	0%	96%
Vending Misers	CLC	4%	0%	0%	96%
Variable Frequency Drives	CLC	14%	0%	0%	86%
Variable Frequency Drives	NSTAR	14%	7%	8%	101%
Variable Frequency Drives	WMECO	6%	1%	0%	95%
Hot Water	NSTAR	0%	98%	0%	198%
Hot Water	WMECO	0%	98%	0%	198%
Process	NSTAR	17%	0%	0%	83%
Process	WMECO	17%	0%	0%	83%
Custom - HVAC	CLC	7%	14%	0%	107%
Custom – Building Envelope	CLC	1%	0%	0%	99%
Custom - Lighting	CLC	9%	6%	0%	97%
Custom – Motors	CLC	14%	0%	0%	86%
Custom – Refrigeration	CLC	4%	0%	0%	96%
Custom – Hot Water	CLC	0%	98%	0%	198%

EVALUATIONS

All factors, are from the National Grid, NSTAR, Western Massachusetts Electric Company, Unitil, and Cape Light Compact 2010 Commercial and Industrial Electric Programs Free-ridership and Spillover Study.[767]

[767] TetraTech (2011). National Grid, NSTAR, Western Massachusetts Electric Company, Unitil, and Cape Light Compact 2010 Commercial and Industrial Electric Programs Free-ridership and Spillover Study. June 23, 2011

Residential Natural Gas Measures					
Measure	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
Residential New Construction & Major Renovation					
Refrigerators	All	86%	0%	0%	14%
ES Homes - Cooling	All	0%	0%	0%	100%
ES Homes - Heating	All	0%	0%	0%	100%
ES Homes - Water Heating	All	0%	0%	0%	100%
Indoor Fixture	All	23%	0%	0%	77%
LED Fixture	All	23%	0%	0%	77%
Screw-in Bulbs	All	23%	0%	0%	77%
Residential Heating and Water Heating					
Boiler (AFUE >= 90%)	All	60%	14%	0%	54%
Boiler (AFUE >= 96%)	All	25%	14%	0%	89%
HTR Boiler (AFUE >= 90%)	All	20%	0%	0%	80%
HTR Boiler (AFUE >= 96%)	All	8%	0%	0%	92%
Boiler Reset Controls	All	0%	0%	0%	100%
HTR Boiler Reset Controls	All	0%	0%	0%	100%
Condensing Water Heater	All	37%	0%	0%	63%
HTR Condensing Water Heater	All	12%	0%	0%	88%
Early Replacement Boiler (Retirement Value)	All	0%	0%	0%	100%
Early Replacement Boiler (HE Value)	All	0%	0%	0%	100%
ES Programmable Thermostats	All	58%	0%	0%	42%
HTR ES Programmable Thermostats	All	19%	0%	0%	81%
Wi-Fi Thermostat	All	0%	0%	0%	100%
Furnace w/ ECM (AFUE = 95%)	All	35%	15%	0%	80%
Furnace w/ ECM (AFUE = 97%)	All	35%	15%	0%	80%
HTR Furnace w/ ECM (AFUE = 95%)	All	12%	0%	0%	88%
HTR Furnace w/ ECM (AFUE = 97%)	All	12%	0%	0%	88%
Heat Recovery Ventilator	All	0%	0%	0%	100%
HTR Heat Recovery Ventilator	All	0%	0%	0%	100%
Indirect Water Heater	All	66%	0%	0%	34%
HTR Indirect Water Heater	All	22%	0%	0%	78%
Integrated water heater/condensing boiler	All	60%	14%	0%	54%
HTR Integrated water heater/condensing boiler	All	20%	0%	0%	80%
Stand Alone Storage Water Heater (EF >= 0.67)	All	37%	0%	0%	63%
HTR Stand Alone Storage Water Heater (EF >= 0.67)	All	12%	0%	0%	88%
Tankless Water Heaters (EF >= 0.82)	All	25%	20%	0%	95%
Tankless Water Heaters (EF >= 0.94)	All	25%	20%	0%	95%
HTR Tankless Water Heaters (EF >= 0.82)	All	8%	0%	0%	92%
HTR Tankless Water Heaters (EF >= 0.94)	All	8%	0%	0%	92%
Home Energy Services (Gas Weatherization)					
Faucet Aerators	All	0%	0%	0%	100%
Low-Flow Shower Heads	All	0%	0%	0%	100%
Air Sealing	All	8%	8%	28%	129%

Exterior Doors	All	0%	0%	0%	100%
Insulation	All	25%	20%	28%	123%
Thermostats	All	11%	0%	0%	89%
Multifamily					
Faucet Aerators	All	15%	0%	0%	85%
Low-Flow Shower Heads	All	15%	0%	0%	85%
Air Sealing	All	19%	0%	0%	81%
Insulation	All	19%	0%	0%	81%
Thermostats	All	24%	0%	0%	76%
Low Income (Single Family and Multifamily)					
Gas Heating System Replacement	All	0%	0%	0%	100%
Gas Weatherization	All	0%	0%	0%	100%
Faucet Aerators	All	0%	0%	0%	100%
Low-Flow Shower Heads	All	0%	0%	0%	100%
Air Sealing	All	0%	0%	0%	100%
Insulation	All	0%	0%	0%	100%
Thermostats	All	0%	0%	0%	100%
Behavior/Feedback Program					
All Groups	NGRID, NSTAR	0%	0%	0%	100%

EVALUATIONS

All NTG factors are set to 100% based on no completed evaluations, unless noted otherwise below.

All PAs base the NTG factors for the Residential New Construction program appliances and lighting measures on the Massachusetts Mini-Baseline Study.[768]

In the Residential Heating and Water Heating program, free-ridership rates are based on the results of the 2010 impact evaluation[769] , the 2011 NTG study[770] or NTGR agreed upon with the PAs and Consultants. The hard-to-reach (HTR) version of each of these measures has assumed free-ridership rates set to 1/3 the value of the non-HTR measure[771].

In the Multifamily program, NTG rates are based on the 2011 NTG Study[772] while Home Energy Services (Gas Weatherization) is based on the results of the 2010 Home Energy Assessment NTG study[773] and the 2011 HES NTG study[774].

[768] NMR Group, Inc., KEMA Inc., Dorothy Conant (2012). Massachusetts Mini-Baseline Study of Homes Built at the end of the 2006 IECC Cycle; June 15, 2012.
[769] Nexus Market Research (2010). HEHE Process and Impact Evaluation. Prepared for GasNetworks
[770] Nexus Market Research (2011). *Estimated Net-To-Gross (NTG) Factors for the Massachusetts Program Administrators (PAs) 2010 Residential New Construction Programs, Residential HEHE and Multi-Family Gas Programs, and Commercial and Industrial Gas Programs.* Prepared for Massachusetts Program Administrators and the Energy Efficiency Advisory Council. Study 11 in the 2010 Massachusetts Electric Energy Efficiency Annual Report
[771] Massachusetts Common Assumption.
[772] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit Multifamily Program Impact Analysis.* Prepared for Massachusetts Program Administrators and the Energy Efficiency Advisory Council; June 2012
[773] Cadmus (2011). *2010 Net-to-Gross Findings: Home Energy Assessment.* The Electric and Gas Program Administrators of Massachusetts. Study 6 in the 2010 Massachusetts Electric Energy Efficiency Annual Report

Commercial Natural Gas Measures						
TRM Measure Group	**Program**	**PA**	**FR**	**SO_P**	**SO_{NP}**	**NTG**
C&I New Construction & Major Renovation						
Gas Condensing Hot Water Boilers		NGRID	19.5%	7.4%	0.2%	88.2%
Gas Condensing Hot Water Boilers		NSTAR	16.0%	3.9%	0.3%	88.2%
Gas Condensing Hot Water Boilers		Columbia	24.0%	0.2%	1.1%	77.2%
Gas Condensing Hot Water Boilers		Berkshire	46.9%	49.4%	0.2%	102.7%
Gas Condensing Hot Water Boilers		NEG	23.0%	0.0%	0.5%	77.5%
Gas Condensing Hot Water Boilers		Unitil	24.5%	0.0%	0.2%	75.7%
Integrated Water Heater/Condensing Boiler (0.90 EF, 0.90 AFUE)		NGRID	19.5%	7.4%	0.2%	88.2%
Integrated Water Heater/Condensing Boiler (0.90 EF, 0.90 AFUE)		NSTAR	16.0%	3.9%	0.3%	88.2%
Integrated Water Heater/Condensing Boiler (0.90 EF, 0.90 AFUE)		Columbia	24.0%	0.2%	1.1%	77.2%
Integrated Water Heater/Condensing Boiler (0.90 EF, 0.90 AFUE)		Berkshire	46.9%	49.4%	0.2%	102.7%
Integrated Water Heater/Condensing Boiler (0.90 EF, 0.90 AFUE)		NEG	23.0%	0.0%	0.5%	77.5%
Integrated Water Heater/Condensing Boiler (0.90 EF, 0.90 AFUE)		Unitil	24.5%	0.0%	0.2%	75.7%
Condensing Stand-Alone Water Heater		NGRID	19.5%	7.4%	0.2%	88.2%
Condensing Stand-Alone Water Heater		NSTAR	16.0%	3.9%	0.3%	88.2%
Condensing Stand-Alone Water Heater		Columbia	24.0%	0.2%	1.1%	77.2%
Condensing Stand-Alone Water Heater		Berkshire	46.9%	49.4%	0.2%	102.7%
Condensing Stand-Alone Water Heater		NEG	23.0%	0.0%	0.5%	77.5%
Condensing Stand-Alone Water Heater		Unitil	24.5%	0.0%	0.2%	75.7%
Furnaces		NGRID	19.5%	7.4%	0.2%	88.2%
Furnaces		NSTAR	16.0%	3.9%	0.3%	88.2%
Furnaces		Columbia	24.0%	0.2%	1.1%	77.2%
Furnaces		Berkshire	46.9%	49.4%	0.2%	102.7%
Furnaces		NEG	23.0%	0.0%	0.5%	77.5%
Furnaces		Unitil	24.5%	0.0%	0.2%	75.7%
Infrared Heaters		NGRID	19.5%	7.4%	0.2%	88.2%
Infrared Heaters		NSTAR	16.0%	3.9%	0.3%	88.2%
Infrared Heaters		Columbia	24.0%	0.2%	1.1%	77.2%
Infrared Heaters		Berkshire	46.9%	49.4%	0.2%	102.7%
Infrared Heaters		NEG	23.0%	0.0%	0.5%	77.5%
Infrared Heaters		Unitil	24.5%	0.0%	0.2%	75.7%
Water Heaters		NGRID	19.5%	7.4%	0.2%	88.2%
Water Heaters		NSTAR	16.0%	3.9%	0.3%	88.2%
Water Heaters		Columbia	24.0%	0.2%	1.1%	77.2%
Water Heaters		Berkshire	46.9%	49.4%	0.2%	102.7%

[774] The Cadmus Group (2012). *Massachusetts 2011 Residential Retrofit and Low Income Net-to-Gross Evaluation.* Prepared for the Electric and Gas Program Administrators of Massachusetts; June, 2012.

Water Heaters	NEG	23.0%	0.0%	0.5%	77.5%
Water Heaters	Unitil	24.5%	0.0%	0.2%	75.7%
Commercial Ovens	NGRID	19.5%	7.4%	0.2%	88.2%
Commercial Ovens	NSTAR	16.0%	3.9%	0.3%	88.2%
Commercial Ovens	Columbia	24.0%	0.2%	1.1%	77.2%
Commercial Ovens	Berkshire	46.9%	49.4%	0.2%	102.7%
Commercial Ovens	NEG	23.0%	0.0%	0.5%	77.5%
Commercial Ovens	Unitil	24.5%	0.0%	0.2%	75.7%
Commercial Griddle	NGRID	19.5%	7.4%	0.2%	88.2%
Commercial Griddle	NSTAR	16.0%	3.9%	0.3%	88.2%
Commercial Griddle	Columbia	24.0%	0.2%	1.1%	77.2%
Commercial Griddle	Berkshire	46.9%	49.4%	0.2%	102.7%
Commercial Griddle	NEG	23.0%	0.0%	0.5%	77.5%
Commercial Griddle	Unitil	24.5%	0.0%	0.2%	75.7%
Commercial Fryers	NGRID	19.5%	7.4%	0.2%	88.2%
Commercial Fryers	NSTAR	16.0%	3.9%	0.3%	88.2%
Commercial Fryers	Columbia	24.0%	0.2%	1.1%	77.2%
Commercial Fryers	Berkshire	46.9%	49.4%	0.2%	102.7%
Commercial Fryers	NEG	23.0%	0.0%	0.5%	77.5%
Commercial Fryers	Unitil	24.5%	0.0%	0.2%	75.7%
Commercial Steamer	NGRID	19.5%	7.4%	0.2%	88.2%
Commercial Steamer	NSTAR	16.0%	3.9%	0.3%	88.2%
Commercial Steamer	Columbia	24.0%	0.2%	1.1%	77.2%
Commercial Steamer	Berkshire	46.9%	49.4%	0.2%	102.7%
Commercial Steamer	NEG	23.0%	0.0%	0.5%	77.5%
Commercial Steamer	Unitil	24.5%	0.0%	0.2%	75.7%
Custom Measures	NGRID	27.9%	9.6%	1.0%	82.7%
Custom Measures	NSTAR	57.5%	11.4%	0.8%	54.7%
Custom Measures	Columbia	7.8%	1.7%	0.4%	94.2%
Custom Measures	Berkshire	3.5%	13.6%	0.0%	110.1%
Custom Measures	NEG	33.1%	8.8%	0.8%	76.5%
Custom Measures	Unitil	33.1%	8.8%	0.8%	76.5%
C&I Retrofit					
Boiler Reset Controls	NGRID	19.5%	7.4%	0.2%	88.2%
Boiler Reset Controls	NSTAR	16.0%	3.9%	0.3%	88.2%
Boiler Reset Controls	Columbia	24.0%	0.2%	1.1%	77.2%
Boiler Reset Controls	Berkshire	46.9%	49.4%	0.2%	102.7%
Boiler Reset Controls	NEG	23.0%	0.0%	0.5%	77.5%
Boiler Reset Controls	Unitil	24.5%	0.0%	0.2%	75.7%
ES Programmable Thermostats	NGRID	19.5%	7.4%	0.2%	88.2%
ES Programmable Thermostats	NSTAR	16.0%	3.9%	0.3%	88.2%
ES Programmable Thermostats	Columbia	24.0%	0.2%	1.1%	77.2%
ES Programmable Thermostats	Berkshire	46.9%	49.4%	0.2%	102.7%
ES Programmable Thermostats	NEG	23.0%	0.0%	0.5%	77.5%

ES Programmable Thermostats	Unitil	24.5%	0.0%	0.2%	75.7%
Pre-Rinse Spray Valve	NGRID	19.5%	7.4%	0.2%	88.2%
Pre-Rinse Spray Valve	NSTAR	16.0%	3.9%	0.3%	88.2%
Pre-Rinse Spray Valve	Columbia	24.0%	0.2%	1.1%	77.2%
Pre-Rinse Spray Valve	Berkshire	46.9%	49.4%	0.2%	102.7%
Pre-Rinse Spray Valve	NEG	23.0%	0.0%	0.5%	77.5%
Pre-Rinse Spray Valve	Unitil	24.5%	0.0%	0.2%	75.7%
Steam Traps	NGRID	19.5%	7.4%	0.2%	88.2%
Steam Traps	NSTAR	16.0%	3.9%	0.3%	88.2%
Steam Traps	Columbia	24.0%	0.2%	1.1%	77.2%
Steam Traps	Berkshire	46.9%	49.4%	0.2%	102.7%
Steam Traps	NEG	23.0%	0.0%	0.5%	77.5%
Steam Traps	Unitil	24.5%	0.0%	0.2%	75.7%
Custom Measures	NGRID	27.9%	9.6%	1.0%	82.7%
Custom Measures	NSTAR	57.5%	11.4%	0.8%	54.7%
Custom Measures	Columbia	7.8%	1.7%	0.4%	94.2%
Custom Measures	Berkshire	3.5%	13.6%	0.0%	110.1%
Custom Measures	NEG	33.1%	8.8%	0.8%	76.5%
Custom Measures	Unitil	33.1%	8.8%	0.8%	76.5%
C&I Direct Install					
ES Programmable Thermostats	NGRID	19.5%	7.4%	0.2%	88.2%
ES Programmable Thermostats	NSTAR	16.0%	3.9%	0.3%	88.2%
ES Programmable Thermostats	Columbia	24.0%	0.2%	1.1%	77.2%
ES Programmable Thermostats	Berkshire	46.9%	49.4%	0.2%	102.7%
ES Programmable Thermostats	NEG	23.0%	0.0%	0.5%	77.5%
ES Programmable Thermostats	Unitil	24.5%	0.0%	0.2%	75.7%
Pre-Rinse Spray Valve	NGRID	19.5%	7.4%	0.2%	88.2%
Pre-Rinse Spray Valve	NSTAR	16.0%	3.9%	0.3%	88.2%
Pre-Rinse Spray Valve	Columbia	24.0%	0.2%	1.1%	77.2%
Pre-Rinse Spray Valve	Berkshire	46.9%	49.4%	0.2%	102.7%
Pre-Rinse Spray Valve	NEG	23.0%	0.0%	0.5%	77.5%
Pre-Rinse Spray Valve	Unitil	24.5%	0.0%	0.2%	75.7%
Faucet Aerators	NGRID	19.5%	7.4%	0.2%	88.2%
Faucet Aerators	NSTAR	16.0%	3.9%	0.3%	88.2%
Faucet Aerators	Columbia	24.0%	0.2%	1.1%	77.2%
Faucet Aerators	Berkshire	46.9%	49.4%	0.2%	102.7%
Faucet Aerators	NEG	23.0%	0.0%	0.5%	77.5%
Faucet Aerators	Unitil	24.5%	0.0%	0.2%	75.7%
Low Flow Shower Heads	NGRID	19.5%	7.4%	0.2%	88.2%
Low Flow Shower Heads	NSTAR	16.0%	3.9%	0.3%	88.2%
Low Flow Shower Heads	Columbia	24.0%	0.2%	1.1%	77.2%
Low Flow Shower Heads	Berkshire	46.9%	49.4%	0.2%	102.7%
Low Flow Shower Heads	NEG	23.0%	0.0%	0.5%	77.5%
Low Flow Shower Heads	Unitil	24.5%	0.0%	0.2%	75.7%

EVALUATIONS

All NTG factors are based on the results of the 2011 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study conducted by TetraTech for the MA Gas PAs.[775] This study developed free-ridership and participant spillover rates for each PA for prescriptive and custom measures. PAs that had fewer than 10 customers surveyed for a program type used the statewide rates.

[775] TetraTech (2012). National Grid, NSTAR, Western Massachusetts Electric Company, Unitil, and Cape Light Compact 2011 Commercial and Industrial Natural Gas Programs Free-ridership and Spillover Study. June 2012

Appendix C: Non-Resource Impacts

Residential Program Non-Energy Impacts

End Use	TRM Measures	NEI	Description	Value or Algorithm	Basis	Duration	Notes on Programs
Lighting	Indoor Fixture Outdoor Fixture LED Fixture	Lighting Quality and Lifetime	O&M savings due to more efficient fixtures	$3.50	per measure	One Time	Not applied for Low Income
	CFL Bulb LED Bulb	Lighting Quality and Lifetime	O&M savings due to more efficient bulbs	$3.00	per measure	One Time	Not applied for Low Income
Products	Refrigerator/ Freezer Recycling, Refrigerator (Retrofit)(Low Income Only), Freezer (Retrofit)	Refrigerator/ Freezer Turn-in	Non-energy benefits of turning in a refrigerator and/or freezer as part of the MA turn-in program. The total benefit is comprised of 3 parts: $1.06 for avoided landfill space, $1.25 for recycling of plastics and glass, and $170.22 for incineration of insulating foam	$172.53	per measure	One Time	Appliance Turn-in programs, Low Income 1-4 and Multifamily programs because replaced units are recycled.
HVAC	Heating System (Retrofit and Rebate)	Improved Safety	Reduced incidence of fire and carbon monoxide exposure as a result of installing a new heating system	$45.05	per measure	Annual	Low Income programs only
	Window AC (Retrofit)	Window Air Conditioner Replacement	Non-energy benefits associated with installing a new room air conditioner replacement	$45.00	per measure	Annual	Low Income programs only
Various	All Measures with oil savings	National Security	Reducing the need for foreign energy imports thereby increasing national security	MMBTU Oil Savings * $1.83	per measure	Annual	Retrofit programs only

	All electric measures with kWh savings and all gas measures with MMBTU savings	Rate Discounts	Financial savings to utility as a result of a smaller portion of energy being sold at the low income rate	**Elec:** (kwh savings per measure)*(R1-R2) **Gas:** (therms savings per measure)*(R3-R4)	per measure	Annual	Low Income programs only

(1) The NEIs in this table represent impacts that accrue specifically measures in the 2012 MA portfolio of programs. Additional NEIs that accrue to participants are used in the benefit - cost analysis of the programs but are not detailed in this manual.
(2) The DHW measures NEI is applied to the DHW ISMs measures that are bundled together and are modeled in units of households, assuming one showerhead and one faucet aerator per household.
(3) Source of NEIs is 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.

New Construction Commercial & Industrial Program Non-Energy Impacts

End Use	TRM Measures	NEI	Description	Value	Basis	Type
Lighting	New Construction CFL O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$17.93	Unit	Annual
	Retrofit CFL O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$18.67	Unit	Annual
	New Construction LED Traffic Light O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$30.02	Unit	Annual
	Retrofit LED Traffic Light O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$29.37	Unit	Annual
	New Construction and Retrofit Control/Sensor O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$6.69	kW Saved	Annual
	Retrofit Fluorescent T8 Lamp-Ballast O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$0.41	Unit	Annual
	Retrofit Fluorescent Super T8 Lamp-Ballast O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$0.06	Unit	Annual
	SBS Retrofit Fluorescent Lamp-Ballast w/ Reflector O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$0.91	Unit	Annual
	Retrofit Exit Sign O&M	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$33.65	Unit	Annual
	WMECO All Lighting Lamps and Fixtures (2)	O&M Savings	Operation & Maintenance savings from fewer replacements over the life of the more efficient measure	$0.009	kWh Saved	Annual

(1) Source is Optimal Energy, Inc. MEMO "Non-Electric Benefits Analysis Update" November 7, 2008.
(2) WMECO counts O&M Benefit per kWh because their tracking system currently does not track fixture counts for all lighting projects.

Retrofit Commercial & Industrial Program Non-Energy Impacts

Fuel	Program	Measure/End Use	NEIs Comprising Value	Value	Basis	Type
Electric	C&I Large Retrofit	Prescriptive Lighting	Administrative Costs, Material Handling, Material Movement, Other Labor Costs, O&M, Sales Revenue, Waste Disposal	$0.027	kWh	Annual
		Prescriptive HVAC	Administrative Costs, Other Costs, Other Labor Costs, O&M, Rent Revenue	$0.097	kWh	Annual
		Custom HVAC	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.024	kWh	Annual
		Custom Lighting	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.059	kWh	Annual
		Refrigeration[776]	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.047	kWh	Annual
		Other	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.056	kWh	Annual
		CHP Systems	Administrative Costs, O&M	$-0.015	kWh	Annual
Electric	C&I Direct Install	HVAC	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.097	kWh	Annual
		Lighting	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.027	kWh	Annual
		Refrigeration	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.047	kWh	Annual
		Other	Administrative Costs, Material Handling, Material Movement, Other Costs, Other Labor Costs, O&M, Product Spoilage, Rent Revenue, Sales Revenue, Waste Disposal	$0.056	kWh	Annual

[776] Prescriptive refrigeration results of *Massachusetts Program Administrators Final Report – Non-Energy Impact Study,* Tetra Tech (2012) were not statistically significant; custom rate used as substitute

Gas	C&I Large Retrofit	Boiler Reset Controls	Administrative Costs, Fees, Material Movement, O&M, Product Spoilage, Rent Revenue	$1.35	Therm	Annual
		Steam Traps	Administrative Costs, Fees, Material Movement, O&M, Product Spoilage, Rent Revenue	$1.35	Therm	Annual
		Thermostats	Administrative Costs, Fees, Material Movement, O&M, Product Spoilage, Rent Revenue	$1.35	Therm	Annual
		Custom	Administrative Costs, Material Movement, Other Costs, other Labor, O&M, Product Spoilage, Waste Disposal	$0.25	Therm	Annual
	C&I Direct Install	Thermostat	Administrative Costs, Fees, Material Movement, O&M, Product Spoilage, Rent Revenue	$1.35	Therm	Annual
		Duct Insulation	Administrative Costs, Fees, Material Movement, O&M, Product Spoilage, Rent Revenue	$1.35	Therm	Annual

(1) Source is KEMA, Inc. (2012). *Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy impacts Study*.

In addition to the NEIs in these tables, the 2011 study of Residential and Low Income NEIs identified a number of participant-based NEIs which are claimed in the 2012 plan. These NEIs and their application are summarized in the tables below.

Per Participant Non-Energy Impacts for Electric Programs

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
Residential New Construction	Thermal Comfort	Greater participant-perceived comfort in home	N/A	$77.00	Annual	Values are applied to the "Heating" measure quantity in this program as an approximation of program participants.
	Noise Reduction	Less participant-perceived noise in the home		$40.00	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home		$72.00	Annual	
Residential Cooling and Heating Equipment	Thermal Comfort	Greater participant-perceived comfort in home	Heating System Cooling System Heating and Cooling System	$48.63 $3.92 $5.05	Annual	Values are applied per participant. Since program participants = rebates, measure category values are counted for every unit. The "heating and cooling system" values are applied to heat pumps.
	Noise Reduction	Less participant-perceived noise in the home	Cooling System Heating and Cooling System	$2.83 $1.42	Annual	
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials	Heating System Cooling System Heating and Cooling System	$17.42 $1.54 $1.98	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment	Heating System Cooling System Heating and Cooling System	$102.40 $7.54 $9.42	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air	Heating System Cooling System	$1.56 $0.13	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
		quality and ease of maintaining healthy relative humidity as a result of weatherization in home	Heating and Cooling System	$0.16		
	Property Value Increase	Increased value of property and expected ease of selling home	Heating System Cooling System Heating and Cooling System	$678.52 $62.65 $80.69	One Time	
MassSave	Thermal Comfort	Greater participant-perceived comfort in home	N/A	$125.00	Annual	
	Noise Reduction	Less participant-perceived noise in the home		$31.00	Annual	
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials		$149.00	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment		$124.00	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home		$4.00	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Property Value Increase	Increased value of property and expected ease of selling home		$1,998.00	One Time	
Multifamily Retrofit	Thermal Comfort	Greater participant-perceived comfort in home	N/A	$125.00	Annual	
	Noise Reduction	Less participant-perceived noise in the home		$31.00	Annual	
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials		$149.00	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment		$124.00	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home		$4.00	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home		$1,998.00	One Time	
Low Income Residential New Construction	Arrearages	Reduced arrearage carrying costs as a result of customers being more able to pay their lower bills	N/A	$2.61	Annual	Values are applied to the "Heating" measure quantity in this program as an approximation of program participants.

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Bad Debt Write-offs	Reduced costs to utility of uncollectable, unpaid balances as a result of customers being more able to pay their lower bills		$3.74	Annual	
	Terminations and Reconnections	Reduced costs associated with terminations and reconnections to utility due to nonpayment as a result of customers being more able to pay their lower bills		$0.43	Annual	
	Customer Calls and Collections	Utility savings in staff time and materials for fewer customer calls as a result of more timely bill payments		$0.58	Annual	
	Notices	Financial savings to utility as a result of fewer notices sent to customers for late payments and terminations		$0.34	Annual	
	Thermal Comfort	Greater participant-perceived comfort in home		$101.00	Annual	
	Noise Reduction	Less participant-perceived noise in the home		$30.00	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials		$35.00	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment		$54.00	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home		$19.00	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home		$949.00	One Time	
Low Income 1 to 4 Family Retrofit	Arrearages	Reduced arrearage carrying costs as a result of customers being more able to pay their lower bills	N/A	$2.61	Annual	
	Bad Debt Write-offs	Reduced costs to utility of uncollectable, unpaid balances as a result of customers being more able to pay their lower bills		$3.74	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Terminations and Reconnections	Reduced costs associated with terminations and reconnections to utility due to nonpayment as a result of customers being more able to pay their lower bills		$0.43	Annual	
	Customer Calls and Collections	Utility savings in staff time and materials for fewer customer calls as a result of more timely bill payments		$0.58	Annual	
	Notices	Financial savings to utility as a result of fewer notices sent to customers for late payments and terminations		$0.34	Annual	
	Thermal Comfort	Greater participant-perceived comfort in home		$101.00	Annual	
	Noise Reduction	Less participant-perceived noise in the home		$30.00	Annual	
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials		$35.00	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment		$54.00	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home		$19.00	Annual	
	Lighting Quality and Lifetime	Increased lighting quality and lifetime with program installed CFLs		$56.00	One Time	
	Property Value Increase	Increased value of property and expected ease of selling home		$949.00	One Time	
	Economic Development	Increased economic benefit due to energy savings		$5.10/ MMBTU and $0.04/kWh	One Time	
	Price Hedging			$0.76/ MMBTU and $0.005/ kWh	One Time	
	Safety-Related Emergency Calls	Financial savings to the utility as a result of fewer safety related emergency calls being made	Heating System	$8.43	Annual	As an approximation of program participants with heating equipment, this value is applied to the 2012 planned quantity for the Heating System Replacement measure.

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
Low Income Multifamily Retrofit	Arrearages	Reduced arrearage carrying costs as a result of customers being more able to pay their lower bills	N/A	$2.61	Annual	
	Bad Debt Write-offs	Reduced costs to utility of uncollectable, unpaid balances as a result of customers being more able to pay their lower bills		$3.74	Annual	
	Terminations and Reconnections	Reduced costs associated with terminations and reconnections to utility due to nonpayment as a result of customers being more able to pay their lower bills		$0.43	Annual	
	Customer Calls and Collections	Utility savings in staff time and materials for fewer customer calls as a result of more timely bill payments		$0.58	Annual	
	Notices	Financial savings to utility as a result of fewer notices sent to customers for late payments and terminations		$0.34	Annual	
	Thermal Comfort	Greater participant-perceived comfort in home		$101.00	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Noise Reduction	Less participant-perceived noise in the home		$30.00	Annual	
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials		$35.00	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment		$54.00	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home		$19.00	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home		$949.00	One Time	
	Economic Development	Increased economic benefit due to energy savings		$5.10/ MMBTU and $0.04/kWh	One Time	
	Price Hedging			$0.76/ MMBTU and $0.005/ kWh	One Time	
	Safety-Related Emergency Calls	Financial savings to the utility as a result of fewer safety related emergency calls being made	Heating System	$8.43	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Rental Units Marketability	Financial savings to owners of LI rental housing as a result of increased marketability of the more efficient housing.	N/A	$0.96	Annual	
	Property Durability	Financial savings to owners of LI rental housing as a result of more durable and efficient materials being installed.		$36.85	Annual	
	Reduced Tenant Complaints	Savings to owners of LI rental housing in terms of staff time and materials as a result of fewer tenant complaints with the more efficient measures.		$19.61	Annual	
	Rental Unit Increased Property Value	Owner-perceived increased property value due to more energy efficient measures		$17.03	One Time	

1. Source is 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.
2. Source of Economic Development NEI is Environment Northeast (2009). Energy Efficiency: Engine of Economic *Growth: A Macroeconomic Modeling Assessment.*
3. Source of Price Hedging NEI is Lawrence Berkeley National Laboratory (2002). *Quantifying the Value That Wind Power Provides as a Hedge Against Volatile Natural Gas Prices.*

Per Participant Non-Energy Impacts for Gas Programs

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
Residential Heating and Hot Water	Thermal Comfort	Greater participant-perceived comfort in home	Heating System Heating and Hot Water System Thermostats	$48.63 $1.83 $3.99	Annual	Values are applied per participant. Since program participants = rebates, measure category values are counted for every unit except for Thermostats which are counted for every 1.15 units. The average number of thermostats installed per participant is 1.15. The "heating and hot water system" values are applied to integrated water heater/condensing boilers.
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials	Heating System Hot Water System Heating and Hot Water System Thermostats	$17.42 $2.13 $0.72 $1.33	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment	Heating System Heating and Hot Water System	$102.40 $3.41	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home	Heating System Heating and Hot Water System Thermostats	$1.56 $0.06 $0.13	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home	Heating System Hot Water System Heating and Hot Water System Thermostats	$678.52 $82.56 $29.17 $51.49	One Time	
Weatherization	Thermal Comfort	Greater participant-perceived comfort in home	N/A	$25.00	Annual	As an approximation of program weatherization participants, values

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Noise Reduction	Less participant-perceived noise in the home		$11.22	Annual	are applied to the 2012 insulation measure quantity.
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials		$9.57	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home		$0.79	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home		$381.28	One Time	
Multifamily Retrofit	Thermal Comfort	Greater participant-perceived comfort in home	Insulation Air Sealing	$25.15 $10.13	Annual	As an approximation of program weatherization participants, values are reduced to 75% and applied to the 2012 air sealing & insulation measure. 75% represents the number of planned
	Noise Reduction	Less participant-perceived noise in the home	Insulation Air Sealing	$11.54 $4.88	Annual	
	Home	Increased	Insulation	$9.82	Annual	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Durability	home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials	Air Sealing	$3.95		units that result in weatherization participants.
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home	Insulation Air Sealing	$0.80 $0.32	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home	Insulation Air Sealing	$378.05 $135.83	One Time	
Residential New Construction	Thermal Comfort	Greater participant-perceived comfort in home	N/A	$77.00	Annual	Values are applied to the "Heating" measure quantity in this program as an approximation of program participants.
	Noise Reduction	Less participant-perceived noise in the home		$40.00	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home		$72.00	Annual	
Low Income Single Family Low Income Multifamily	Arrearages	Reduced arrearage carrying costs as a result of customers being more able to pay their lower bills	N/A	$2.61	Annual	Values are applied to program participants.

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Bad Debt Write-offs	Reduced costs to utility of uncollectable, unpaid balances as a result of customers being more able to pay their lower bills		$3.74	Annual	
	Terminations and Reconnections	Reduced costs associated with terminations and reconnections to utility due to nonpayment as a result of customers being more able to pay their lower bills		$0.43	Annual	
	Customer Calls and Collections	Utility savings in staff time and materials for fewer customer calls as a result of more timely bill payments		$0.58	Annual	
	Notices	Financial savings to utility as a result of fewer notices sent to customers for late payments and terminations		$0.34	Annual	
	Safety-Related Emergency Calls	Financial savings to the utility as a result of fewer safety related emergency calls being made	Heating System	$8.43	Annual	As an approximation of program participants with heating equipment, this value is applied to the 2012 planned quantity for the Heating System Replacement measure.
	Thermal	Greater	Insulation	$25.38	Annual	As an

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
	Comfort	participant-perceived comfort in home	Air Sealing Heating System	$30.23 $28.01		approximation of program participants receiving each of these measure category values, insulation and air sealing values were applied to the Weatherization measure (LI SF) or the Air Sealing & Insulation Measure (LI MF) and heating system values were applied to the Heating System Replacement measure.
	Noise Reduction	Less participant-perceived noise in the home	Insulation Air Sealing	$13.56 $16.39	Annual	
	Home Durability	Increased home durability in terms of maintenance requirements because of better quality heating, cooling and structural materials	Insulation Air Sealing Heating System	$8.76 $10.61 $9.72	Annual	
	Equipment Maintenance	Reduced maintenance costs of owning newer and/or more efficient appliance equipment	Heating System	$27.43	Annual	
	Health Benefits	Fewer colds and viruses, improved indoor air quality and ease of maintaining healthy relative humidity as a result of weatherization in home	Insulation Air Sealing Heating System	$4.77 $5.69 $5.27	Annual	
	Property Value Increase	Increased value of property and expected ease of selling home	Insulation Air Sealing Heating System	$223.63 $144.93 $249.20	One Time	

Program	NEI	Description	Measure Category	Value	Duration	Notes on Model Application
Additional NEIs for Low Income Multifamily	Rental Units Marketability	Financial savings to owners of LI rental housing as a result of increased marketability of the more efficient housing.	Air Sealing	$0.07	Annual	Values are applied to the 2012 planned quantity for Air Sealing with the assumption that one air sealing job is done per household.
	Property Durability	Financial savings to owners of LI rental housing as a result of more durable and efficient materials being installed.		$2.58	Annual	
	Reduced Tenant Complaints	Savings to owners of LI rental housing in terms of staff time and materials as a result of fewer tenant complaints with the more efficient measures.		$1.37	Annual	
	Rental Unit Increased Property Value	Owner-perceived increased property value due to more energy efficient measures		$1.19	One Time	

Source is 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.

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Appendix E: Acronyms

ACRONYM	DESCRIPTION
AC	Air Conditioning
AFUE	Annual Fuel Utilization Efficiency (see the Glossary)
AHU	Air Handling Unit
Btu	British Thermal Unit (see the Glossary)
CF	Coincidence Factor (see the Glossary)
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
COP	Coefficient of Performance (see the Glossary)
DCV	Demand Controlled Ventillation
DHW	Domestic Hot Water
DOER	Department of Energy Resources
DSM	Demand Side Management (see the Glossary)
ECM	Electrically Commutated Motor
EER	Energy Efficiency Ratio (see the Glossary)
EF	Efficiency Factor
EFLH	Equivalent Full Load Hours (see the Glossary)
ES	ENERGY STAR® (see the Glossary)
FCM	Forward Capacity Market
FR	Free-Ridership (see the Glossary)
HE	High-Efficiency
HID	High-Intensity Discharge (a lighting technology)
HP	Horse Power (see the Glossary)
HSPF	Heating Seasonal Performance Factor (see the Glossary)
HVAC	Heating, Ventilating, and Air Conditioning
ISO	Independent System Operator
ISR	In-Service Rate (see the Glossary)
kW	Kilo-Watt, a unit of electric demand equal to 1,000 watts
kWh	Kilowatt-Hour, a unit of energy (1 kilowatt of power supplied for one hour)
LED	Light-Emitting Diode (one type of solid-state lighting)
LCD	Liquid Crystal Display (a technology used for computer monitors and similar displays)
MMBtu	One million British Thermal Units (see “Btu” in the Glossary)
MW	Megawatt – a measure of electric demand equal to 1,000 kilowatts
MWh	Megawatt-hour – a measure of energy equal to 1,000 kilowatt-hours
NEB	Non-Electric Benefit (see the Glossary)
NEI	Non-Energy Impact
NE-ISO	New England Independent System Operator
NTG	Net-to-Gross (see the Glossary)
O&M	Operations and Maintenance
PA	Program Administrator (see the Glossary)
PARIS	Planning And Reporting Information System (a DOER database - see the Glossary)
PC	Personal Computer
RR	Realization Rate (see the Glossary)
SEER	Seasonal Energy Efficiency Ratio (see the Glossary)
SO	Spillover (see the Glossary)
SPF	Savings Persistence Factor (see the Glossary)
SSL	Solid-State Lighting (e.g., LED lighting)
VSD	Variable-Speed Drive

Appendix F: Glossary

This glossary provides definitions as they are applied in this TRM for Massachusetts' energy efficiency programs. Alternate definitions may be used for some terms in other contexts.

TERM	DESCRIPTION
Adjusted Gross Savings	Gross savings (as calculated by the measure savings algorithms) that have been subsequently adjusted by the application of all impact factors except the net-to-gross factors (free-ridership and spillover). For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.
AFUE	Annual Fuel Utilization Efficiency. The measure of seasonal or annual efficiency of a furnace or boiler. AFUE takes into account the cyclic on/off operation and associated energy losses of the heating unit as it responds to changes in the load, which in turn is affected by changes in weather and occupant controls.
Baseline Efficiency	The level of efficiency of the equipment that would have been installed without any influence from the program or, for retrofit cases where site-specific information is available, the actual efficiency of the existing equipment.
Btu	British thermal unit. A Btu is approximately the amount of energy needed to heat one pound of water by one degree Fahrenheit.
Coefficient of Performance (COP)	Coefficient of Performance is a measure of the efficiency of a heat pump, air conditioner, or refrigeration system. A COP value is given as the Btu output of a device divided by the Btu input of the device. The input and output are determined at AHRI testing standards conditions designed to reflect peak load operation.
Coincidence Factor (CF)	Coincidence Factors represent the fraction of connected load expected to occur concurrent to a particular system peak period; separate CF are found for summer and winter peaks. The CF given in the TRM includes both coincidence and diversity factors multiplied into one number. Coincidence factors are provided for peak periods defined by the NE-ISO for FCM purposes and calculated consistent with the FCM methodology.
Connected Load kW Savings	The connected load kW savings is the power saved by the equipment while in use. In some cases the savings reflect the maximum power draw of equipment at full load. In other cases the connected load may be variable, which must be accounted for in the savings algorithm.
Deemed Savings	Savings values (electric, fossil fuel and/or non-energy benefits) determined from savings algorithms with assumed values for all algorithm parameters. Alternatively, deemed savings values may be determined from evaluation studies. A measure with deemed savings will have the same savings per unit since all measure assumptions are the same. Deemed savings are used by program administrators to report savings for measures with well-defined performance characteristics relative to baseline efficiency cases. Deemed savings can simplify program planning and design, but may lead to over- or under-estimation of savings depending on product performance.
Deemed Calculated Savings	Savings values (electric, fossil fuel and/or non-energy benefits) that depend on a standard savings algorithm and for which at least one of the algorithm parameters (e.g., hours of operation) is project specific.
Demand Savings	The reduction in demand due to installation of an energy efficiency measure, usually expressed as kW and measured at the customer's meter (see Connected Load kW Savings).
Demand Side Management (DSM)	Strategies used to manage energy demand including energy efficiency, load management, fuel substitution, and load building.
Diversity	A characteristic of a variety of electric loads whereby individual maximum demands occur at different times. For example, 50 efficient light fixtures may be installed, but they are not necessarily all on at the same time. See Coincidence Factor.

TERM	DESCRIPTION
Diversity Factor	This TRM uses coincidence factors that incorporate diversity (See Coincidence Factor), thus this TRM has no separate diversity factors. A diversity factor is typically calculated as: 1) the percent of maximum demand savings from energy efficiency measures available at the time of the company's peak demand, or 2) the ratio of the sum of the demands of a group of users to their coincident maximum demand.
End Use	Refers to the category of end use or service provided by a measure or technology (e.g., lighting, cooling, etc.). For the purpose of this manual, end uses with their PARIS codes include: ALght Lighting HVAC HVAC CMoDr Motors & Drives DRefr Refrigeration EHoWa Hot Water FComA Compressed Air GProc Process* HEUBe Behavior Ienvl Insulation & Air Sealing JGchp Combined Heat & Power KSdhw Solar Hot Water LDmdR Demand Response MPvEl Photovoltaic Panels *For residential measures, "process" is used for products that have low savings, such as consumer electronics, or do not conform to existing end use categories. For commercial and industrial measures, "process" is used for systematic improvements to manufacturing or pump systems, or efficient models of specialty equipment not covered in other end uses.
Energy Efficiency Ratio (EER)	The Energy Efficiency Ratio is a measure of the efficiency of a cooling system at a specified peak, design temperature, or outdoor temperature. In technical terms, EER is the steady-state rate of heat energy removal (i.e. cooling capacity) of a product measured in Btuh output divided by watts input.
ENERGY STAR® (ES)	Brand name for the voluntary energy efficiency labeling initiative sponsored by the U.S. Environmental Protection Agency.
Energy Costing Period	A period of relatively high or low system energy cost, by season. The energy periods defined by ISO-NE are: • **Summer Peak**: 6am–10pm, Monday–Friday (except ISO holidays), June–September • **Summer Off-Peak:** Summer hours not included in the summer peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, June–September • **Winter Peak:** 6am–10pm, Monday–Friday (except ISO holidays), January–May and October–December • **Winter Off-Peak:** Winter hours not included in the sinter peak hours: 10pm–6am, Monday–Friday, all day on Saturday and Sunday, and ISO holidays, January–May and October–December.
Equivalent Full Load Hours (EFLH)	The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).
Free Rider	A customer who participates in an energy efficiency program, but would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available.
Free-Ridership Rate	The percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.
Gross kW	Expected demand reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.
Gross kWh	Expected kWh reduction based on a comparison of standard or replaced equipment and equipment installed through an energy efficiency program.

TERM	DESCRIPTION
Gross Savings	A saving estimate calculated from objective technical factors. In this TRM, "gross savings" are calculated with the measure algorithms and do not include any application of impact factors. Once impact factors are applied, the savings are called "Adjusted Gross Savings". For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.
High Efficiency (HE)	Refers to the efficiency measures that are installed and promoted by the energy efficiency programs.
Horsepower (HP)	A unit for measuring the rate of doing work. One horsepower equals about three-fourths of a kilowatt (745.7 watts).
Heating Seasonal Performance Factor (HSPF)	A measure of the seasonal heating mode efficiencies of heat pumps expressed as the ratio of the total heating output to the total seasonal input energy.
Impact Factor	Generic term for a value used to adjust the gross savings estimated by the savings algorithms in order to reflect the actual savings attributable to the efficiency program. In this TRM, impact factors include realization rates, in-service rates, savings persistence, peak demand coincidence factors, free-ridership, spillover and net-to-gross factors. See the section on Impact Factors for more detail.
In-Service Rate	The percentage of units that are actually installed. For example, efficient lamps may have an in-service rate less than 100% since some lamps are purchased as replacement units and are not immediately installed. The in-service rate for most measures is 100%.
Measure Life	The number of years that an efficiency measure is expected to garner savings. These are generally based on engineering lives, but sometimes adjusted based on observations of market conditions.
Lost Opportunity	Refers to a measure being installed at the time of planned investment in new equipment or systems. Often this reflects either new construction, renovation, remodeling, planned expansion or replacement, or replacement of failure.
Measure	A product (a piece of equipment), combination of products, or process designed to provide energy and/or demand savings. Measure can also refer to a service or a practice that provides savings. Measure can also refer to a specific combination of technology and market/customer/practice/strategy (e.g., direct install low income CFL).
Net Savings	The final value of savings that is attributable to a program or measure. Net savings differs from gross savings (or adjusted gross savings) because it includes adjustments due to free-ridership and/or spillover. Net savings is sometimes referred to as "verified" or "final" savings. For more detail see the section on Impact Factors for Calculating Adjusted Gross and Net Savings.
Net-to-Gross Ratio	The ratio of net savings to the adjusted gross savings (for a measure or program). The adjusted gross savings include any adjustment by the impact factors other than free-ridership or spillover. Net-to-gross is usually expressed as a percent.
Non-Electric Benefits (NEBs)	Quantifiable benefits (beyond electric savings) that are the result of the installation of a measure. Fossil fuel, water, and maintenance are examples of non-electric benefits. Non-electric benefits can be negative (i.e. increased maintenance or increased fossil fuel usage which results from a measure) and therefore are sometimes referred to as "non-electric impacts".
Non-Participant	A customer who is eligible to participate in a program, but does not. A non-participant may install a measure because of a program, but the installation of the measure is not through regular program channels; as a result, their actions are normally only detected through evaluations.
On-Peak kW	See Summer/Winter On-peak kW
Operating Hours	Hours that a piece of equipment is expected to be in operation, not necessarily at full load (typically expressed per year).

TERM	DESCRIPTION
PARIS	Planning And Reporting Information System, a statewide database maintained by the Department of Energy Resources (DOER) that emulates the program administrators' screening model. As a repository for quantitative data from plans, preliminary reports, and reports, PARIS generates information that includes funding sources, customer profiles, program participation, costs, savings, cost-effectiveness and program impact factors from evaluation studies. DOER developed PARIS in 2003 as a collaborative effort with the Department of Public Utilities and the electric program administrators. Beginning with the 2010 plans, PARIS holds data from gas program administrators.
Participant	A customer who installs a measure through regular program channels and receives any benefit (i.e. incentive) that is available through the program because of their participation. Free-riders are a subset of this group.
Prescriptive Measure	A prescriptive measure is generally offered by use of a prescriptive form with a prescribed incentive based on the parameters of the efficient equipment or practice.
Program Administrator (PA)	Those entities that oversee public benefit funds in the implementation of energy efficiency programs. This generally includes regulated utilities, other organizations chosen to implement such programs, and state energy offices. The Massachusetts electric PAs include Cape Light Compact, National Grid, NSTAR, Western Massachusetts Electric Company (WMECo), and Unitil. The Massachusetts natural gas PAs include Bay State Gas, Berkshire Gas, and New England Gas.
Realization Rate (RR)	The ratio of measure savings developed from impact evaluations to the estimated measure savings derived from the TRM savings algorithms. This factor is used to adjust the estimated savings when significant justification for such adjustment exists. The components of the realization rate are described in detail in the section on Impact Factors.
Retrofit	The replacement of a piece of equipment or device before the end of its useful or planned life for the purpose of achieving energy savings. "Retrofit" measures are sometimes referred to as "early retirement" when the removal of the old equipment is aggressively pursued.
Savings Persistence Factor (SPF)	Percentage of first-year energy or demand savings expected to persist over the life of the installed energy efficiency equipment. The SPF is developed by conducting surveys of installed equipment several years after installation to determine the operational capability of the equipment. In contrast, *measure persistence* takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor.
Seasonal Energy Efficiency Ratio (SEER)	A measurement of the efficiency of a central air conditioner over an entire season. In technical terms, SEER is a measure of equipment the total cooling of a central air conditioner or heat pump (in Btu) during the normal cooling season as compared to the total electric energy input (in watt-hours) consumed during the same period.
Seasonal Peak kW	See Summer/Winter Seasonal Peak kW, and Summer/Winter On-Peak Peak kW.
Sector	A system for grouping customers with similar characteristics. For the purpose of this manual, the sectors are Commercial and Industrial (C&I), Small Business, Residential, and Low Income.
Spillover Rate	The percentage of savings attributable to the program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of (a) participants in the program who install additional energy efficient measures outside of the program as a result of hearing about the program and (b) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program.
Summer/Winter On-Peak kW	The average demand reduction during the summer/winter on-peak period. The summer on-peak period is 1pm-5pm on non-holiday weekdays in June, July and August; the winter on-peak period is 5pm-7pm on non-holiday weekdays in December and January.

TERM	DESCRIPTION
Summer/Winter Seasonal Peak kW	The demand reduction occurring when the actual, real-time hourly load for Monday through Friday on non-holidays, during the months of June, July, August, December, and January, as determined by the ISO, is equal to or greater than 90% of the most recent 50/50 system peak load forecast, as determined by the ISO, for the applicable summer or winter season.
Ton	Unit of measure for determining cooling capacity. One ton equals 12,000 Btu.
Watt	A unit of electrical power. Equal to 1/1000 of a kilowatt.