# Massachusetts
# Technical Reference Manual

for Estimating Savings from Energy Efficiency Measures

2010 Program Year – Report Version

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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 National Grid consistently, reliably, and transparently calculate savings from the installation of efficient equipment or the installation of efficient equipment, collectively called "measures," over the course of the 2010 program year. 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) engineering judgment to develop credible and realistic factors.

[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.

# 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.

### 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.

### 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 | |

### 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.

**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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

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

| | Full Program Name | Abbreviation |
|---|---|---|
| Residential-Electric | Residential New Construction & Major Renovation | RNC |
| | Residential Cooling & Heating Equipment | RHVAC |
| | Multi-Family Retrofit | MF Retrofit |
| | MassSAVE | MassSAVE |
| | OPOWER | 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 |
| | OPOWER Program | Behavior/Feedback |
| Low Income – Electric | 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 |

# Impact Factors for Calculating Adjusted Gross and Net Savings

National Grid uses 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 the Glossary (see Appendix D: Glossary).

## Types of Impact Factors

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

Impact factors used to adjust gross savings:

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

Impact factors used to calculate net savings:

- Free-Ridership ("FR") and Spillover ("SO") Rates
- Net-to-Gross Ratios ("NTG").

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

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

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

The **realization rate** is used to adjust the gross savings (as calculated by the savings algorithms) based on impact evaluation studies. The realization rate is equal to the ratio of measure savings developed from an

impact evaluation to the estimated measure savings derived from the savings algorithms. The realization rate does not include the effects of any other impact factors. Depending on the impact evaluation study, there may be separate realization rates for 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 the on-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:

- 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

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

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

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

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

## Standard Net–to–Gross Formulas

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

**Calculation of Net Annual Electric Energy Savings**

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

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

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

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

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

**Calculation of Net Annual Natural Gas Energy Savings**

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

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) |
| $adj\_gross\_kW_{WP}$ | = | 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 |

# Residential Electric Efficiency Measures

# Lighting – CFL Bulbs (Markdown)

### Measure Overview

**Description:** This measure covers the installation of ENERGY STAR® screw-in compact fluorescent lamps (CFLs) purchased through the PAs markdown programs. 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:** One Time Non-Resource
**Sector:** Residential
**Market:** Lost Opportunity
**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 CFL Bulb Spiral |
| ΔkWh | = | Average annual kWh reduction: 47 kWh |
| ΔkW | = | Average annual kW reduction: 0.0457 kW[2] |
| Hours | = | Average annual operating hours |

### 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 are 1,022 hours/year (2.8 hours/day[3] * 365 days/year).

### Measure Life

The measure life is 7 years for markdown bulbs and 5 years for coupon bulbs.[4]

[2] Nexus Market Research (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT; Page 56.
[3] Ibid.
[4] Nexus Market Research, Inc., RLW Analytics (2008). *Residential Lighting Measure Life Study*. Prepared for New England Residential Lighting Program Sponsors.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| One-Time Non-Resource | O&M Cost Impacts[5] | $3.00/Bulb |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Screw-in Bulbs | ES Lighting | 0.42 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| Screw-in Bulbs (Hard to Reach) | ES Lighting | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| Screw-in Bulbs (School Fundraiser) | ES Lighting | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| Screw-in Bulbs (Specialty) | ES Lighting | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |

**In-Service Rates**
In-service rates are based on Study 8, Evaluation of Residential Lighting Program, for Screw-in-Bulbs, hard to reach, and specialty measures.[6] Note- these are NTG values shown here to remain consistent with the National Grid tracking system.

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

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

**Coincidence Factors**
Coincidence factors are from the 2009 Lighting Markdown Study.[7]

[5] Massachusetts Electric Utilities (2003). *Non-Electric Benefit Performance Metrics – Residential 1*. Memo to Massachusetts non-Electric Parties.
[6] NMR (2011). *Massachusetts ENERGY STAR ® Lighting Program: 2010 Annual Report.* Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council. Study 8 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.
[7] 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.

# Lighting – CFL Bulbs

### Measure Overview

**Description:** The installation of ENERGY STAR® screw-in compact fluorescent lamps (CFLs). 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**: One Time O&M Cost Reduction, Low Income only: Annual Discounted Rate Cost Reduction
**Sector**: Residential, Low Income
**Market**: Lost Opportunity, Retrofit
**End Use**: Lighting
**Program**: Residential New Construction & Major Renovation, MassSAVE, Low-Income Residential New Construction, Low-Income 1-4 Family Retrofit

### Algorithms for Calculating Primary Energy Impact

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

*For Residential New Construction & Major Renovation, MassSAVE, and Low-Income Residential New Construction:*

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

Unit = Installed CFL bulb
ΔkWh = Average annual kWh reduction: 57 kWh
ΔkW = Average reduction in connected kW: 0.049 kW[8]
Hours = Average annual operating hours

*For Low-Income 1-4 Family Retrofit:*

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

Where:
Unit = Installed CFL bulb
ΔkWh = Average annual kWh savings per unit: 41 kWh[9]
ΔkW = Max kW reduction: 0.011 kW[10]

[8] Nexus Market Research, Inc., RLW Analytics (2004). *Impact Evaluation of the MA, RI, and VT 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.
[9] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Table 1, Page 5.
[10] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.

### Baseline Efficiency

The baseline efficiency case is an incandescent bulb.

### High Efficiency

The high efficiency case is an ENERGY STAR® qualified compact fluorescent light bulb that uses 75% less energy and lasts about 10 times longer than an incandescent bulb.

### Hours

The annual operating hours are 1,168 hours/year (3.2 hours/day[11] * 365 days/year).

### Measure Life

For Residential New Construction & Major Renovation, MassSAVE, and Low-Income Residential New Construction installations, the measure life is 7 years.[12]

For Low-Income 1-4 Family Retrofit installations the measure life is 9 years.[13]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impact

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[14] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | O&M Cost Reduction[15] | $3/Bulb | |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Screw-in Bulbs | RNC, LI RNC | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| Screw-in Bulbs | MassSAVE | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.076 | 0.286 |
| Screw-in Bulbs (piggyback) | MassSAVE | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 0.076 | 0.286 |
| CFL Bulb | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 1.00 |

**In-Service Rate**

- RNC, LI RNC: 2006 ENERGY STAR® Homes New Homebuyer Survey Report.[16]

[11] Ibid.
[12] Nexus Market Research, Inc., RLW Analytics (2008). *Residential Lighting Measure Life Study*. New England Residential Lighting Program Sponsors.
[13] Massachusetts Common Assumption: In the Low Income program there is no limit on the number of CFLs installed per home; a longer lifetime is assumed to account for the shorter hours per day.
[14] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[15] Massachusetts Electric Utilities (2003). *Non-Electric Benefit Performance Metrics – Residential 1*. Memo to Massachusetts non-Electric Parties.
[16] Nexus Market Research (2007). *2006 Energy Star Homes New Home Buyer Survey Report, Final Report, March 30, 2007.* Prepared for the Massachusetts Joint Management Committee.

- MassSAVE: Impact evaluation of the MA, RI, VT 2003 Residential Lighting Programs[17]
- LI 1-4 Retrofit: Assume 100% installation rate.

**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**
- RNC, LI RNC, MassSAVE: Coincidence factors are based on the 2009 Lighting Markdown Study.[18]
- LI 1-4 Retrofit: Coincidence factors are estimated using the demand allocation methodology described in the 2000 EnergyWise program impact evaluation.[19]

[17] Nexus Market Research, Inc., RLW Analytics (2004). *Impact Evaluation of the MA, RI, and VT 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.
[18] 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.
[19] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Lighting – CFL Indoor Fixtures

## 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**: One-Time O&M Cost Reduction, Annual Discounted Rate Cost Reduction (Low Income only)
**Sector:** Low Income, Residential
**Market:** Lost Opportunity, Retrofit
**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 deemed based on study results:

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

Where:

| | | |
|---|---|---|
| Unit | = | Rebated indoor fixture |
| ΔkWh | = | Average annual kWh reduction: 44 kWh |
| ΔkW | = | Average reduction in connected kW: 0.049 kW[20] |
| Hours | = | Average annual operating hours |

## 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[21] * 365 days/year).

[20] Nexus Market Research, Inc., RLW Analytics (2004) *Impact Evaluation of the MA, RI, and VT 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, Table 1-8.

### Measure Life

The measure life is 20 years.[22]

### Secondary Energy Impact

There are no secondary energy impacts for this measure.

### Non-Energy Impact

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[23] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | O&M Cost Reduction[24] | $3.50/Fixture | |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Indoor Fixture | ES Lighting | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| Indoor Fixture | RNC, LI RNC | 0.96 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |

**In-Service Rates**
- ES Lighting: 2004 Impact Evaluation of MA, RI, VT Residential Lighting Program[25]
- RNC, LI RNC: 2006 ENERGY STAR® Homes New Homebuyer Survey Report[26]

**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 for CFL fixtures are estimated using the demand allocation methodology described in the 2000 EnergyWise program impact evaluation.[27] Coincidence factors for indoor fixtures are based on the 2009 Lighting Markdown Study.[28]

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[21] Nexus Market Research, Inc., RLW Analytics (2004) *Impact Evaluation of the MA, RI, and VT 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.
[22] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Lighting Fixtures*. Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LF.
[23] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[24] Massachusetts Electric Utilities (2003). *Non-Electric Benefit Performance Metrics – Residential 1*. Memo to Massachusetts non-Electric Parties.
[25] Nexus Market Research, Inc., RLW Analytics (2004). *Impact Evaluation of the MA, RI, and VT 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.
[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 Joint Management Committee; Table 8.1
[27] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.
[28] 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.

# Lighting – Outdoor Fixtures

### 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:** One-time Non-Resource
**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 |
| ΔkW | = | Average connected kW reduction: 0.095 kW[29] |
| 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 bulb.

### Hours

The average annual operating hours are 1,642.5 hours/year (4.5 hours per day[30] * 365 days per year).

[29] Nexus Market Research, Inc., RLW Analytics (2004). *Impact Evaluation of the MA, RI, and VT 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.
[30] Nexus Market Research, Inc., RLW Analytics (2004). *Impact Evaluation of the MA, RI, and VT 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

### Measure Life

The measure life is 6 years for markdown outdoor fixtures and 5 years for coupon outdoor fixtures.[31]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| One-Time Non-Resource | O&M Cost Impacts[32] | $3.50/Bulb |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Outdoor Fixture | ES Lighting | 0.87 | 1.00 | 100 | 1.00 | 1.00 | 0.11 | 0.22 |

**In-Service Rates**
2004 Impact Evaluation of MA, RI, VT Residential Lighting Program.[33]

**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.[34]

[31] Nexus Market Research, Inc., RLW Analytics (2008). *Residential Lighting Measure Life Study*. Prepared for New England Residential Lighting Program Sponsors; Page 1.
[32] Massachusetts Electric Utilities (2003). *Non-Electric Benefit Performance Metrics – Residential 1*. Memo to Massachusetts non-Electric Parties.
[33] Nexus Market Research, Inc., RLW Analytics (2004) *Impact Evaluation of the MA, RI, and VT 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.
[34] 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.

# Lighting – Torchieres

### 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:** Annual Discounted Rate Cost Reduction (Low Income only)
**Sector:** Residential, Low Income
**Market:** Lost Opportunity, Retrofit
**End Use:** Lighting
**Program:** ENERGY STAR Lighting

### Algorithms for Calculating Primary Energy Impact

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: 106 kWh |
| ΔkW | = | Average connected kW reduction: 0.088 kW[35] |
| 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[36] * 365 days/year).

### Measure Life

The measure life is 8 years.[37]

[35] Nexus Market Research, Inc., RLW Analytics (2004) *Impact Evaluation of the MA, RI, and VT 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.
[36] Nexus Market Research, Inc., 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

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Torchieres | ES Lighting | 0.83 | 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[38]

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

**Realization Rates**
Realization rates are based on Staff Assumptions.

**Coincidence Factors**
Coincidence factors are based on the 2009 Lighting Markdown Study.[39]

[37] Ibid.
[38] Nexus Market Research, Inc., RLW Analytics (2004). *Impact Evaluation of the MA, RI, and VT 2003 Residential Lighting Programs.* Submitted to The Cape Light Compact, State of Vermont Public Service Department for Efficiency Vermont Service Department for Efficiency Vermont, National Grid, Northeast Utilities, NSTAR, and Unitil Energy Systems, Inc.; Page 11.
[39] 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.

# Lighting – Light–Emitting Diode Lights

### 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:** Annual Discounted Rate Cost Reduction (Low Income only)
**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:

$$\Delta kWh = \left(kW_{BASE} - kW_{LED}\right) \times Hours$$
$$\Delta kW = \Delta kW$$

Where:

| | | |
|---|---|---|
| Unit | = | Rebated LED lamp or fixture |
| ΔkWh | = | Average annual energy savings: 48 kWh[40] |
| ΔkW | = | Average connected kW reduction: 0.013 kW[41] |
| $kW_{BASE}$ | = | Average connected kW of baseline bulb |
| $kW_{LED}$ | = | Average connected kW of LED bulb |
| Hours | = | Average annual operating hours |

### 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.

### Hours

The average annual operating hours are 1,022 hours/year (2.8 hours/day[42] * 365 days/year).

[40] 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.*
[41] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[42] Nexus Market Research (2009). *Residential Lighting Markdown Impact Evaluation*. Prepared for Markdown and Buydown Program Sponsors in CT, MA, RI, and VT; Page 6.

### Measure Life

The measure life is 20 years.[43]

### Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[44] | $(R1-R2)/kWh | Low Income |

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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| LED Lamp | ES Lighting | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| LED Fixture | ES Lighting | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.11 | 0.22 |
| LED Fixture | RNC, LI RNC | 1.00 | 1.00 | 0.73 | 0.73 | 0.73 | 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.[45]

[43] Expected lifetime form ENERGY STAR ®.
[44] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[45] 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.

# Process – Computer Monitors

### Measure Overview

**Description:** Rebates for ENERGY STAR® Computer Monitors
**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 study results:

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

Where:

| | | |
|---|---|---|
| Unit | = | Rebated ENERGY STAR® computer monitor |
| ΔkWh | = | Average annual kWh savings per unit: 35 kWh[46] |
| ΔkW | = | Average annual kW savings per unit: 0.010 kW[47] |

### Baseline Efficiency

The baseline efficiency case is a conventional computer monitor.

### High Efficiency

The high efficiency case is an ENERGY STAR® rated LCD monitor.

### Hours

Not applicable.

### Measure Life

The measure life is 6 years.[48]

[46] Deemed savings developed based on assumptions in CEE (2008). *Consumer Electronics Program Guide: Information on Voluntary Approaches for the Promotion of Energy Efficient Consumer Electronics - Products and Practices*; Page 9, Table 1.
[47] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[48] CEE (2008). *Consumer Electronics Program Guide: Information on Voluntary Approaches for the Promotion of Energy Efficient Consumer Electronics - Products and Practices.*

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Computer Monitors | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 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**
Coincidence factors are based on Massachusetts Common Assumptions.

# Process – Desktop Computers

### Measure Overview

**Description:** Rebates for ENERGY STAR® Desktop 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: 76 kWh[49]
ΔkW = Average kW savings per unit: 0.01 kW[50]

### Baseline Efficiency

The baseline efficiency case is a conventional desktop computer.

### High Efficiency

The high efficiency case is an ENERGY STAR® rated desktop computer.

### Hours

The operational hours include: 3,322 annual idle hours, 399 annual sleep hours, and 5,039 annual off hours.[51]

### Measure Life

The measure life is 4 years.[52]

[49] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Office Equipment.* Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_office_eq.xls.
[50] Ibid.
[51] Ibid.
[52] 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| PC Computers | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 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**
Coincidence factors are based on Massachusetts Common Assumptions.

# Process – Room Air Cleaner

### 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: 268 kWh[53] |
| ΔkW | = | Average connected load reduction: 0.032 kW[54] |
| 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 8,760 operating hours per year.

### Measure Life

The measure life is 9 years.[55]

[53] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Room Air Cleaner.* Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls
[54] Ibid.
[55] 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Room Air Cleaner | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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**
Coincidence factors are based on Massachusetts Common Assumptions.

# Process – Smart Strips

### 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:** Annual Discounted Rate Cost Reduction (Low Income only)
**Sector:** Residential, Low Income
**Market:** Lost Opportunity, Retrofit
**End Use:** Process
**Program:** ENERGY STAR Appliances

### 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: 75 kWh[56]
ΔkW = Max kW savings per unit: 0.060 kW

### 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

The savings are based on 8,760 hours per year.

### Measure Life

The measure life is 5 years.[57]

### Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

[56] ECOS 2008 Entertainment Center and DVDs.
[57] Massachusetts Common Assumptions.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Smart Strips | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 1.00 |
| Smart Strips | MF Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 1.00 |
| Smart Strips | LI MF Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 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**
Coincidence factors are based on Massachusetts Common Assumptions.

# Process – Televisions

### Measure Overview

**Description:** Rebates for televisions that meet ENERGY STAR® version 4.1 and 5.1 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:

$$\Delta kWh = kWh_{BASE} - kWh_{EE}$$
$$\Delta kW = kW_{BASE} - kW_{EE}$$

Where:

| | | |
|---|---|---|
| Unit | = | Rebated television |
| $kWh_{BASE}$ | = | Average kW consumption of baseline models |
| $kWh_{EE}$ | = | Average kWh consumption of energy efficient models |
| $kW_{BASE}$ | = | Average kW load of baseline models |
| $kW_{EE}$ | = | Average kW load of energy efficient models |

### Baseline Efficiency

The baseline efficiency case is a CEE Tier 1 television.

### High Efficiency

The high efficiency case is an ENERGY STAR® qualified television, which uses about 40% less energy than standard units. Qualifying ENERGY STAR® TV products include standard TVs, HD-ready TVs, and the large flat-screen plasma TVs.[58] The savings, which are weighted between on and standby modes, are given in the following table.

| Television Size | Weighted kW Savings | ΔkWh /Unit |
|---|---|---|
| LCD/TV | 0.022 | 194 |

### 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.

[58] Homes: Energy Star. *Televisions for Consumers.* http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=TV. Accessed on 10/11/10.

### Measure Life

The measure life is 6 years.[59]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impact

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| LCD/TV | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.85 |

**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.

[59] Environmental Protection Agency (2008). Life *Cycle Cost Estimate for ENERGY STAR Television*. Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Televisions_Bulk.xls

# Refrigeration – Refrigerators (Lost Opportunity)

### 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:** Annual Discounted Rate Cost Reduction (Low Income only)
**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: 107 kWh[60] |
| ΔkW | = | Average kW reduction over non-ES refrigerator: 0.014 kW[61] |

### Baseline Efficiency

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

### 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.

### Hours

Not applicable.

[60] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator*. Interactive Excel Spreadsheet found at www.energystar.gov/.../business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls; average of savings form all refrigerator models.
[61] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.

### Measure Life

The measure life is 12 years.[62]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[63] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Refrigerator Rebate | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |
| Refrigerators | RNC, LI RNC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |

**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.

[62] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator*. Interactive Excel Spreadsheet found at www.energystar.gov/.../business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls
[63] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*

# Refrigeration – Refrigerators (Retrofit)

## 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:** Low Income only: Annual Discounted Rate Cost Reduction, One-Time Avoided Refrigerator Purchase
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** Refrigeration
**Program:** MassSAVE, Low-Income 1-4 Family Retrofit

## Algorithms for Calculating Primary Energy Impact

*For MassSAVE:*

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

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

Where:

| | | |
|---|---|---|
| Unit | = | Replacement of existing refrigerator with new ENERGY STAR® Refrigerator |
| $\Delta kWh_{RETIRE}$ | = | Annual energy savings over remaining life of existing equipment: 884 kWh[64] |
| $\Delta kWh_{ES}$ | = | Annual energy savings over full life of new ES refrigerator: 80 kWh[65,66] |
| $\Delta kW_{RETIRE}$ | = | Average demand reduction over remaining life of existing equipment: 0.030 kW[67] |
| $\Delta kW_{ES}$ | = | Average demand reduction over full life of new ES refrigerator: 0.010 kW[68] |

*For Low-Income 1-4 Family Retrofit:*

Unit savings are deemed based on study results:

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

[64] Michael Blasnik & Associates (2004). *Measurement & Verification of Residential Refrigerator Energy Use 2003 - 2004 Metering Study*. Prepared for NSTAR MECO, NECO, and WMECO.
[65] Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator. Interactive Excel Spreadsheet found at www.energystar.gov/.../business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls
[66] NSTAR uses the Lost Opportunity savings of 107 kWh as the annual savings over the life of the new ES refrigerator. See *Refrigerator (Lost Opportunity) section.*
[67] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[68] Ibid.

Where:
Unit = Removal of existing refrigerator and installation of new efficient refrigerator
ΔkWh = Average annual kWh savings per unit: 1,122 kWh[69]
ΔkW = Max kW Reduction: 0.148 kW[70]

**Baseline Efficiency**

*For MassSAVE:*
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.[71]

*For Low-Income 1-4 Family 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.

**Hours**

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

**Measure Life**

For MassSAVE the remaining life of the existing refrigerator is 1 year, and the measure life for the new refrigerator is 12 years. [72] For Low-Income 1-4 Family Retrofit the measure life is 19 years.[73]

**Secondary Energy Impacts**

There are no secondary energy impacts for this measure.

[69] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Page 5, Table 1.
[70] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[71] 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.
[72] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator*. Interactive Excel Spreadsheet found at www.energystar.gov/.../business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls.
[73] Massachusetts Common Assumption.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[74] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | One-Time Avoided Refrigerator Purchase[75] | $200/Unit | Low Income 1-4 Family Retrofit only |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Refrigerators | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |
| Refrigerator Replacement | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |

**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**
- MassSAVE: 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**
Coincidence factors are estimated using the demand allocation methodology described in the 2000 EnergyWise program impact evaluation.[76]

[74] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[75] Ibid.
[76] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Refrigeration – Freezers (Lost Opportunity)

### 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:

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

Where:

| | | |
|---|---|---|
| Unit | = | Installed ENERGY STAR® freezer |
| ΔkWh | = | Annual savings over non-ES freezers averaged by model type: 136 kWh[77] |
| ΔkW | = | Average kW reduction over non-ES freezer: 0.018 kW[78] |

### Baseline Efficiency

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

### 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.

### Hours

Not applicable.

### Measure Life

The measure life is 12 years.[79]

[77] NEEP. *Refrigerator and Freezer Screening Tool*; average savings of all given models.
[78] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[79] Massachusetts Common Assumption: it has been assumed that LI customers would replace with a used inefficient unit so the full savings are counted for the full lifetime.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impact

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Freezer Rebate | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |

**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.

# Refrigeration – Freezers (Retrofit)

### 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:** Low Income only: Annual Discounted Rate Cost Reduction, One-Time Avoided Refrigerator Purchase
**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 existing freezer and installation of new efficient freezer
ΔkWh = Average annual kWh savings per unit: 637 kWh[80]
ΔkW = Max kW Reduction: 0.084 kW[81]

### 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.

### Measure Life

The measure life is 19 years.[82]

[80] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Page 5, Table 1.
[81] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[83] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | One-Time Avoided Refrigerator Purchase[84] | $200/Unit | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Freezer Replacement | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |

**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 2000 EnergyWise program impact evaluation.[85]

[82] Massachusetts Common Assumption: it has been assumed that LI customers would replace with a used inefficient unit so the full savings are counted for the full lifetime.
[83] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[84] Ibid.
[85] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Refrigeration – Refrigerator/Freezer Recycling

### Measure Overview

**Description:** The retirement of old, inefficient secondary refrigerators and freezers.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**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.

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

Where:

| | | |
|---|---|---|
| Unit | = | Removed secondary refrigerator or freezer |
| ΔkWh | = | Average annual kWh savings per unit: 490 kWh[86] |
| ΔkW | = | Average kW reduction per unit: 0.08 kW[87] |

### 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.

### 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.[88]

[86] Nexus Market Research, Group (2011). *Evaluation of Appliance Recycling Program.* Prepared for Massachusetts Energy Efficiency Program Administrators. Study 9 in the 2010 Electric Energy Efficiency Annual Report. Weighted average of refrigerators and freezers rebated in 2010.
[87] Ibid.
[88] 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Ref Frz Recycling | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |

**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 Massachusetts Common Assumptions.

# Refrigeration – Appliance Removal

### Measure Overview

**Description:** Removal of second working refrigerator or freezer.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** Annual Discounted Rate Cost Reduction
**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: 1,321 kWh[89]
ΔkW = Max kW reduction: 0.174 kW [90]

### 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.

### Measure Life

The measure life is 5 years.[91]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[89] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program*. Prepared for National Grid; average of refrigerator and freezer removal, Table 15.
[90] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[91] Massachusetts Common Assumption.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[92] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Appliance Removal | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 |

**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 2000 EnergyWise program impact evaluation.[93]

[92] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[93] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Refrigeration – Basic Educational Measures

### 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:** Annual Discounted Rate Cost Reduction, One-Time Arrearage Reduction
**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: 138 kWh[94]
ΔkW = Max kW Reduction: 0.038 kW[95]

### Baseline Efficiency

The baseline efficiency case assumes no measures installed.

### High Efficiency

The high efficiency case includes basic educational measures such as CFLs, low flow showerheads, pool and air conditioner timers, torchieres, and programmable thermostats.

### Hours

Not applicable.

### Measure Life

The measure life is 5 years.[96]

[94] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[95] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[96] Massachusetts Common Assumption.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[97] | $(R1-R2)/kWh | Low Income |
| Annual Non-Resource | Annual Fire, Illness and Moving Avoidance Benefits[98] | $100.48 /Participant | Low Income |
| One-Time Non-Resource | One-Time Arrearage Reduction[99] | $70/Participant | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Baseload | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 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 2000 EnergyWise program impact evaluation.[100]

[97] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[98] Ibid.
[99] Ibid.
[100] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# HVAC – Central Air Conditioning

### Measure Overview

**Description:** The installation of high efficiency Central AC 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:

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

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

Where:

| | | |
|---|---|---|
| Unit | = | Installation of central AC system |
| Tons | = | Cooling capacity of AC equipment: Current default is 3 tons[101] |
| $SEER_{BASE}$ | = | Seasonal Energy Efficiency Ratio of baseline AC equipment |
| $SEER_{EE}$ | = | Seasonal Energy Efficiency Ratio of new efficient AC equipment |
| $EER_{BASE}$ | = | Energy Efficiency Ratio of base AC equipment |
| $EER_{EE}$ | = | Energy Efficiency Ratio of new efficient AC equipment |
| Hours | = | Equivalent full load hours |

The savings for this measure are given in the table below.[102]

| Measure | kW Savings | kWh Savings |
|---|---|---|
| CoolSmart AC (SEER 14.5 / EER 12) | 0.273 | 103 |

### Baseline Efficiency

The baseline efficiency case is a 13 SEER Central AC system with an EER of 11.

### High Efficiency

The high efficiency case is an ENERGY STAR® qualified Central AC system. The high efficiency case has a 14.5 SEER and 12 EER.

[101] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-12, Table 4-9.
[102] The PAs are looking into abilities to track and calculate savings based on actual installed efficiencies for each project.

### 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

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart AC | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

[103] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; 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.

# HVAC – Air Source Heat Pump

## Measure Overview

**Description:** The installation of high efficiency Air Source Heat Pumps.
**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:

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

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

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

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

Where:
Unit = Installation of heat pump system
Tons = Capacity of HP equipment: Current default is 3 tons[105]
$SEER_{BASE}$ = Seasonal efficiency of baseline HP equipment
$SEER_{EE}$ = Seasonal efficiency of new efficient HP equipment
$EER_{BASE}$ = Peak efficiency of base HP equipment
$EER_{EE}$ = Peak efficiency of new efficient HP 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

Deemed savings for 2010:

| Measure | $SEER_{EE}$ | $EER_{EE}$ | $HSPF_{EE}$ | kW Savings | kWh Savings |
|---|---|---|---|---|---|
| CoolSmart HP (SEER 14.5 / EER 12) | 14.5 | 12 | 8.2 | 0.347 | 519 |
| CoolSmart HP (SEER >= 15.0 / EER 12) | 15 | 12 | 8.5 | 0.502 | 735 |

[105] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis*. Prepared for CL&P; Page 4-12, Table 4-9.

### Baseline Efficiency

The baseline efficiency case is a heat pump with a HSPF of 7.6, SEER of 13, and EER of 11.

### High Efficiency

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

### Hours

Equivalent full load hours are 1200 hours/year for heating[106] and 360 hours/year for cooling.[107]

### Measure Life

The measure life is 18 years.[108]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart HP | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 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.

[106] Massachusetts Common Assumption.
[107] ADM Associates, Inc. (2009). Residential *Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-5, Table 4-3.
[108] 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.

# HVAC – Ductless Mini Split Heat Pump

## 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**: 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:

$$\Delta kWh = \Delta kWh_{HP} + \Delta kWh_{DuctSealing}$$

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

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

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

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

Where:

| | | |
|---|---|---|
| Unit | = | Installation of high efficiency ductless Mini Split System |
| $\Delta kWh_{HP}$ | = | Reduction in annual kWh consumption of HP equipment |
| $\Delta kW_{HP}$ | = | Reduction in electric demand of HP equipment |
| $\Delta kWh_{DuctSealing}$ | = | Annual energy savings from duct sealing: See *HVAC – Duct Sealing* |
| $\Delta kW_{DuctSealing}$ | = | Annual demand reduction from duct sealing: See *HVAC – Duct Sealing* |
| Tons | = | Capacity of HP equipment: Current default is 3 tons[109] |
| $SEER_{BASE}$ | = | Seasonal efficiency of baseline HP equipment |
| $SEER_{EE}$ | = | Seasonal efficiency of new efficient HP equipment, assumed to be 15 SEER |
| $EER_{BASE}$ | = | Peak efficiency of base HP equipment |
| $EER_{EE}$ | = | Peak efficiency of new efficient HP equipment, assumed to be 12.5 EER |
| $HSPF_{BASE}$ | = | Heating efficiency of baseline HP equipment |
| $HSPF_{EE}$ | = | Heating efficiency of new efficient HP equipment, assumed to be 8.2 EER |
| $Hours_C$ | = | EFLH for cooling |
| $Hours_H$ | = | EFLH for heating |

[109] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-12, Table 4-9.

### Baseline Efficiency

The baseline efficiency case is a non- ENERGY STAR® rated ductless mini split heat pump.

### High Efficiency

The high efficiency case is an ENERGY STAR® qualified Ductless Mini Split System. The savings for 2010 are listed in the table below. [110]

| Measure | kW Savings | kWh Savings |
|---|---|---|
| CoolSmart HP Mini Split (SEER 15 / EER 12.5) | 0.693 | 761 |

### Hours

The equivalent full load hours are 1200 hours/year for heating[111] and 360 hours/year for cooling.[112]

### Measure Life

The measure life is 18 years.[113]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Ductless Mini Split HP | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 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.

[110] These numbers are late correction and are not reflected in the reported savings. The reported savings are based on 1.039 kW and 720 kWh.
[111] Massachusetts Common Assumptions.
[112] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis*. Prepared for CL&P; Page 4-5, Table 4-3.
[113] 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.

# HVAC – Central AC Quality Installation Verification (QIV)

### 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
Tons = Cooling capacity of AC equipment: Current default is 3 tons [114]
SEER = Seasonal efficiency of AC equipment
EER = Peak efficiency of AC equipment
Hours = Equivalent full load hours
5% = Average percent demand reduction: 5.0%[115]

### Baseline Efficiency

The baseline efficiency case is a system whose installation is inconsistent with manufacturer specifications.

### High Efficiency

The high efficiency case is a system whose installation is consistent with manufacturer specifications. The measure savings for 2010 are listed in the table below:

| Measure | kW Savings | kWh Savings |
|---|---|---|
| CoolSmart AC QIV ES and NES | 0.164 | 50 |

[114] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-12, Table 4-9.
[115] Massachusetts Common Assumption.

### Hours

Equivalent full load cooling hours are 360 hours per year.[116]

### Measure Life

The measure life is 18 years.[117]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart AC QIV ES | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 0.00 |
| CoolSmart AC QIV NES | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

[116] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-5, Table 4-3.
[117] 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.

# HVAC – Heat Pump Quality Installation Verification (QIV)

### 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 |
| Tons | = | Cooling capacity of HP equipment: Current default is 3 tons [118] |
| 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%[119] |

### Baseline Efficiency

The baseline efficiency case is a system whose installation is inconsistent with manufacturer specifications.

[118] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-12, Table 4-9.
[119] Massachusetts Common Assumption.

### High Efficiency

The high efficiency case is a system whose installation is consistent with manufacturer specifications. The measure savings for 2010 are listed in the table below:

| Measure | kW Savings | kWh Savings |
|---|---|---|
| CoolSmart HP QIV ES and NES | 0.237 | 334 |

### 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.[120]

### Measure Life

The measure life is 18 years.[121]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart HP QIV ES | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.59 | 0.50 |
| CoolSmart HP QIV NES | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.59 | 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.

[120] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-5, Table 4-3.
[121] 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.

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

### 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
Tons = Cooling capacity of AC equipment: Current default is 3 tons[122]
SEER = Seasonal efficiency of AC equipment, assumed to be 10 SEER.
EER = Peak efficiency of AC equipment, assumed to be 8.5 EER.
Hours = Equivalent full load hours
5% = Average demand reduction: 5%[123]

### Baseline Efficiency

The baseline efficiency case is a system that does not operate according to manufacturer specifications.

### High Efficiency

The high efficiency case is a system that operates according to manufacturer specifications. The measure savings for 2010 are listed in the table below:

| Measure | kW Savings | kWh Savings |
|---|---|---|
| CoolSmart AC Digital Check-up/Tune-up | 0.212 | 65 |

[122] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-12, Table 4-9.
[123] Massachusetts Common Assumption.

### Hours

The equivalent full load cooling hours are 360 hours per year.[124]

### Measure Life

The measure life is 5 years.[125]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart AC Digital Check-up/Tune-up | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

[124] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-5, Table 4-3.
[125] 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.

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

### 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 |
| Tons | = | Cooling capacity of HP equipment: Current default is 3 tons[126] |
| SEER | = | Seasonal cooling efficiency of HP equipment, assumed to be 10 SEER. |
| EER | = | Peak cooling efficiency of HP equipment, assumed to be 8.5 EER. |
| HSPF | = | Heating efficiency of HP equipment, assumed to be 7 HSPF. |
| $Hours_C$ | = | EFLH for cooling |
| $Hours_H$ | = | EFLH for heating |
| 5% | = | Average demand reduction: 5%[127] |

### Baseline Efficiency

The baseline efficiency case is a system that does not operating according to manufacturer specifications.

### High Efficiency

The high efficiency case is a system that does operate according to manufacturer specifications. The measure savings for 2010 are listed in the table below:

[126] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis.* Prepared for CL&P; Page 4-12, Table 4-9.
[127] Massachusetts Common Assumption.

| Measure | kW Savings | kWh Savings |
|---|---|---|
| CoolSmart AC Digital Check-up/Tune-up | 0.257 | 373 |

### Hours

The equivalent full load hours are 1200 hours per year for heating[128] and 360 hours per year for cooling.[129]

### Measure Life

The measure life is 5 years[130]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart HP Digital Check-up/Tune-up | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 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.

[128] Massachusetts Common Assumptions.
[129] ADM Associates, Inc. (2009). Residential Central AC Regional Evaluation – Free-Ridership Analysis. Prepared for CL&P; Page 4-5, Table 4-3.
[130] 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.

# HVAC – Duct Sealing

### 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[131]:

$$\Delta kWh = \Delta kWh$$

$$\Delta kW = \Delta kW$$

Where:
Unit = Completed job
ΔkWh = Average annual kWh reduction based on DOE2 modeling[132]: 212 kWh
ΔkW = Average annual kW reduction based on DOE2 modeling[133]: 0.300 kW

### 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.

### Measure Life

The measure life is 18 years.[134]

[131] The PAs are looking into abilities to track and calculate savings based on project-specific detail.
[132] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*; Page 3, Table 2.
[32] Ibid.

[134] 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.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Duct Sealing | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

# HVAC – Down Size ½ Ton

### Measure Overview

**Description:** Reduction in system size consistent with manual J calculations.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact**: One-Time Cost Reduction
**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
ΔkWh/Ton = Average annual kWh reduction based on DOE2 modeling[135]: 203 kWh
ΔkW/Ton = Average annual kW reduction based on DOE2 modeling[136]: 0.030 kW

### 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.

### Measure Life

The measure life is 18 years.[137]

[135] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*; Page 3, Table 2.
[136] Ibid.
[137] 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.

### Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| One-Time Non-Resource | O&M Cost savings due to smaller size unit (by ½ ton) that is purchased compared to the unit that would have been purchased.[138] | $300/Unit |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Down Size ½ Ton | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

[138] Massachusetts Common Assumption.

# HVAC – Right Sizing

### 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**: O&M
**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 kWh reduction based on DOE2 modeling[139]: 123 kWh |
| ΔkW | = | average annual kW reduction based on DOE2 modeling[140]: 0.150 kW |

### 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.

### Measure Life

The measure life is 18 years.[141]

[139] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*; Page 3, Table 2.
[140] Ibid.
[141] 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.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| One-Time Non-Resource | O&M Cost savings due to smaller size unit (by ½ ton) that is purchased compared to the unit that would have been purchased. [142] | $30/Unit |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Right Sizing | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

[142] Massachusetts Common Assumptions

# HVAC – Early Replacement of Central AC or Heat Pump Unit

## 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**: None
**Sector:** Residential
**Market:** Retrofit
**End Use:** HVAC
**Program:** Residential Cooling & Heating Equipment

## Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on engineering estimates and assumptions:

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

Where:
Unit = Replacement of existing inefficient system with new efficient system
ΔkWh = Average kWh savings per unit listed in table below.
ΔkW = Average kW savings per unit listed in table below.

The measure savings for 2010 are listed in the table below:

| Measure | kW Savings | kWh Savings |
|---|---|---|
| Early Replacement of AC Equipment | 0.963 | 415 |
| Early Replacement of HP Equipment | 1.235 | 876 |

## Baseline Efficiency

The baseline efficiency case is assumed to be a typical 10-12 years old AC or heat pump unit.

## High Efficiency

The high efficiency case is a code compliant central AC or HP unit.

## Hours

The equivalent full load hours are 1,200 hours per year for heating[143] and 360 hours per year for cooling.[144]

[143] Massachusetts Common Assumptions.
[144] ADM Associates, Inc. (2009). *Residential Central AC Regional Evaluation – Free-Ridership Analysis*. Prepared for CL&P; Page 4-5, Table 4-3.

### Measure Life

The measure life is 7 years.[145]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Early Replacement of AC Equipment | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 0.00 |
| Early Replacement of HP Equipment | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 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.

[145] 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.

# HVAC – Quality Installation with Duct Sealing

### 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 kWh reduction based on DOE2 modeling[146]: 513 kWh with duct modifications, 212 kWh without duct modifications |
| ΔkW | = | Average annual kW reduction based on DOE2 modeling[147]: 0.850 kW with duct modifications, 0.300 kW without duct modifications |

### 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.

### Hours

Not applicable.

### Measure Life

The measure life is 18 years.[148]

[146] RLW Analytics (2002). *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*; Page 3, Table 2.
[147] 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Energy Star QI | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 0.00 |
| Energy Star QI w/ Duct modifications | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.85 | 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 Massachusetts Common Assumptions.

[148] 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.

# HVAC – Warm Air Furnace Electronically Commutated Motor (ECM)

### Measure Overview

**Description:** Installation of an electronically commutated variable speed air supply motor.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** NG – Res Heating
**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 ECM
ΔkWh = Gross annual kWh savings from the measure: 600 kWh[149]
ΔkW = Gross connected kW savings from the measure: 0.116 kW[150]

### 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.

### Hours

Not applicable.

### Measure Life

The measure life is 18 years.[151]

### Secondary Energy Impacts

This is the increased heating load as a result of a more efficient motor.

[149] Sachs, Harvey (2003). *Energy Savings form Efficient Furnace Air Handlers in Massachusetts.*
[150] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[151] Sachs, Harvey (2003). *Energy Savings form Efficient Furnace Air Handlers in Massachusetts.*

| Measure | Energy Type | Savings | ΔMMBtu/Unit |
|---|---|---|---|
| CoolSmart Warm Air Furnace ECM | NG – Residential Heating | -1.575 MMBtu[152] | -1.575 |

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CoolSmart Warm Air Furnace ECM | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 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.

[152] Ibid. An adjustment is made to the savings value of 2.3 MMBtu given in the study. The original savings value is multiplied by 420 heating hours divided by 600 total running hours (420/600 = 0.70). An AFUE adjustment of 90/92 is also multiplied to the original value to create a more realistic final value.

# HVAC – Brushless Furnace Fan Motor

### Measure Overview

**Description:** Installation of a high efficiency steady state brushless furnace fan motor.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** Gas
**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 BFF motors
ΔkWh = Gross annual kWh savings: 600 kWh[153]
ΔkW = Gross connected kW savings: 0.116 kW[154]

### 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.

### Measure Life

The measure life is 18 years.[155]

### Secondary Energy Impacts

This is the increased heating load as a result of a more efficient motor.

[153] Sachs, Harvey (2003). *Energy Savings form Efficient Furnace Air Handlers in Massachusetts.*
[154] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[155] 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.

| Measure | Energy Type | Savings | ΔMMBtu/Unit |
|---|---|---|---|
| Brushless Furnace Fan Motor | NG – Residential Heating | -1.575 MMBtu[156] | -1.575 |

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Brushless Furnace Fan Motor | RHVAC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 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.

[156] Sachs, Harvey (2003). *Energy Savings form Efficient Furnace Air Handlers in Massachusetts*. An adjustment is made to the savings value of 2.3 MMBtu given in the study. The original savings value is multiplied by 420 heating hours divided by 600 total running hours (420/600 = 0.70). An AFUE adjustment of 90/92 is also multiplied to the original value to create a more realistic final value.

# HVAC – Room AC (Lost Opportunity)

### 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:

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

Where:

| | | |
|---|---|---|
| Unit | = | Rebated room AC unit |
| ΔkWh | = | Average annual kWh savings per unit: 49 kWh[157] |
| ΔkW | = | Average demand reduction per unit: 0.24 kW |
| Hours | = | Equivalent full load hours |

### Baseline Efficiency

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

### High Efficiency

The high efficiency level is a room AC unit meeting or exceeding the federal efficiency standard by 10% or more. Average size and EERs is estimated from rebated units in previous year and updated annually.

### Hours

Equivalent full load hours are 200 hours per year.[158]

[157] 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.
[158] RLW Analytics (2008). *Coincidence Factor Study Residential 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.

### Measure Life

The measure life is 9 years.[159]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Room AC (Upstream) | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.134 | 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**
All PAs use CFs from a 2008 residential room AC coincidence factor study.[160]

[159] 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.
[160] RLW Analytics (2008). *Coincidence Factor Study Residential Air Conditioners.* Prepared for Northeast Energy Efficiency Partnerships' New England Evaluation and State Program Working Group.

# HVAC – Window AC Replacement (Retrofit)

### 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:** Annual Discounted Rate Cost Reduction, Annual Participant Benefit
**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 = Removal of existing window AC unit and installation of new efficient window AC unit
ΔkWh = Average annual kWh savings per unit: 100 kWh[161]
ΔkW = Max load kW reduction: 0.214 kW[162]

### 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.

### Measure Life

The measure life is 12 years.[163]

[161] Quantec, LLC (2005). *Evaluation of National Grid's 2003 Appliance Management Program: Room Air Conditioning Metering and Non-Energy Benefits Study*. Prepared for National Grid.
[162] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[163] 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.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impact

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[164] | $(R1-R2)/kWh | Low Income |
| Annual Non-Resource | Annual participant benefit including comfort, safety, and health effects[165] | $104/unit | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Window AC Replacement | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.02 |

**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 2000 EnergyWise program impact evaluation.[166]

[164] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[165] Quantec, LLC (2005). *Evaluation of National Grid's 2003 Appliance Management Program: Room Air Conditioning Metering and Non-Energy Benefits Study*. Prepared for National Grid; Page iv-19.
[166] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# HVAC – Electric Weatherization

### 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:** Annual Discounted Rate Cost Reduction, One-Time Arrearage Reduction, Annual Fire, Illness and Moving Avoidance Benefits, One-Time Property Value Benefit
**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: 374 kWh[167]
ΔkW = Average annual kW reduction: 0.047 kW[168]

### 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.

### Measure Life

The measure life is 20 years.[169]

[167] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Table 1.
[168] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[169] Massachusetts Common Assumption.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[170] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | The One-Time Property Value Benefit[171] | $20.70 x ($Cost/kWh) x kWh Saved | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Electric Weatherization | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.03 | 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 2000 EnergyWise program impact evaluation.[172]

[170] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[171] Ibid.
[172] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# HVAC – Oil Weatherization

### Measure Overview

**Description:** Installation of weatherization measures such as air sealing and insulation in oil heated homes. Electric savings are achieved from reduced fan run time for heating and cooling systems.
**Primary Energy Impact:** Oil
**Secondary Energy Impact:** Electric
**Non-Energy Impact:** Annual Discounted Rate Cost Reduction, One-Time Arrearage Reduction, Annual Fire, Illness and Moving Avoidance Benefits, One-Time Property Value Benefit
**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 heated household with weatherization measures installed |
| ΔkWh | = | Average annual kWh reduction: 70 kWh[173] |
| ΔkW | = | Average annual kW reduction: 0.009 kW[174] |

### 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.

### Measure Life

The measure life is 20 years.[175]

[173] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[174] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[175] 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.

### Secondary Energy Impacts

| Measure | Energy Type | Savings[176] | ΔMMBtu/Unit |
|---|---|---|---|
| Oil Weatherization | Oil | 98 gallons/home | 13.7 |

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[177] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | The One-Time Property Value Benefit (Electric)[178] | $20.70 x ($Cost/kWh) x kWh Saved | Low Income |
| One-Time Non-Resource | The One-Time Property Value Benefit (Oil)[179] | $20.70 x ($Cost/gal Oil) x gal Oil Saved | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Oil Weatherization | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.03 | 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 2000 EnergyWise program impact evaluation.[180]

[176] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[177] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[178] Ibid.
[179] Ibid.
[180] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# HVAC – Heating System Replacement (Oil)

### 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:** Annual Discounted Rate Cost Reduction, One-Time Arrearage Reduction, Annual Fire, Illness and Moving Avoidance Benefits, One-Time Property Value Benefit
**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: 194 kWh[181] |
| ΔkW | = | Average annual kW reduction per unit: 0.024 kW[182] |

### 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.[183]

[181] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[182] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[183] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*. Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls.

### Secondary Energy Impacts

| Measure | Energy Type | Savings | ΔMMBtu/Unit |
|---|---|---|---|
| Heating System Replacement (Oil) | Oil | 87 Gallons/home[184] | 12.2 |

### Non-Energy Impacts

| Benefit Type | Description | Savings[185] | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | One-Time Property Value Benefit (Electric) | $20.70 x $Cost/kWh x kWh Saved | Low Income |
| One-Time Non-Resource | One-Time Property Value Benefit (Oil) | $20.70 x $Cost/gal Oil x gal Oil Saved | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Heating System Replacement (Oil) | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.03 | 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 2000 EnergyWise program impact evaluation.[186]

[184] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[185] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[186] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# HVAC/Hot Water – ENERGY STAR® Homes Heating, Cooling, and DHW Measures

## 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:** Annual Discounted Rate Cost Reduction (Low Income only)
**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

As part of the ENERGY STAR® certification process, 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. This process is documented in "Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR® Homes Program."[187]

## Baseline Efficiency

The User Defined Reference Home was revised for 2006 as a result of the baseline study completed in 2006.[188]

## 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.

[187] ICF (2008). *Energy/Demand Savings Calculation and Reporting Methodology for the Massachusetts ENERGY STAR ® Homes Program.* Prepared for Joint Management Committee.
[188] Nexus Market Research & Dorothy Conant (2006). Massachusetts ENERGY STAR ® Homes: 2005 Baseline Study: Part I: Inspection Data Analysis Final Report. Prepared for Joint Management Committee. AND 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 Joint Management Committee.

### Measure Life

| Measure Type | Measure Life (years)[189] |
|---|---|
| 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 | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[190] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | One Time Arrearage Reduction[191] | $35/Participant | Low Income heating measures only |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| ES Homes – Cooling | RNC, LI RNC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | custom | custom |
| ES Homes – Heating | RNC, LI RNC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | custom | custom |
| ES Homes – Water Heating | RNC, LI RNC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 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 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.

[189] Massachusetts Common Assumption.
[190] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[191] Ibid.

# Hot Water – Domestic Hot Water Measures (Electric)

### 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, Annual Discounted Rate Cost Reduction
**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: 134 kWh[192] |
| ΔkW | = | Average annual kW reduction per unit: 0.017 kW[193] |

### 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.[194]

[192] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[193] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[194] Massachusetts Common Assumption.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Residential Water | Residential water savings per participant | 8,785 Gallons/Participant | |
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[195] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| DHW Measures (Electric) | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.75 | 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 2000 EnergyWise program impact evaluation.[196]

[195] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[196] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Hot Water – Domestic Hot Water Measures (Oil and Gas)

### 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, Annual Discounted Rate Cost Reduction
**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.[197]

### Secondary Energy Impacts

| Measure | Energy Type | Savings[198] | ΔMMBtu/Unit |
|---|---|---|---|
| DHW Measures (Gas) | NG – Residential DHW | 9 Therms | 0.9 |
| DHW Measures (Oil) | Oil | 6.4 Gallons | 0.9 |

[197] Massachusetts Common Assumption.
[198] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Residential Water | Residential water savings per participant | 8,785 Gallons/Participant | |
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[199] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| DHW Measures (Gas/Other) | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| DHW Measures (Oil) | LI 1-4 Retrofit | 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 estimated using the demand allocation methodology described in the 2000 EnergyWise program impact evaluation.[200]

[199] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[200] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Hot Water – Dishwashers

## Measure Overview

**Description:** Installation of ENERGY STAR® qualified dishwashers in residential homes during new construction or major renovation. ENERGY STAR® dishwashers are on average, 10% more energy-efficient than non-qualified models.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** Natural Gas, Oil, Propane
**Non-Energy Impact:** Water Savings, Low Income only: Annual Discounted Rate Cost Reduction
**Sector:** Residential
**Market:** Lost Opportunity
**End Use:** Hot Water
**Program:** Residential New Construction & Major Renovation, Low-Income Residential New Construction

## Algorithms for Calculating Primary Energy Impact

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

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

Where:
Unit = Installation of ENERGY® dishwasher
ΔkWh = National Grid gross average annual kWh savings per unit[201]: 28 kWh for RNC, 25 kWh for LI RNC
ΔkW = Average annual kW savings per unit[202]: 0.003 kW
$kWh_{BASE}$ = Average unit energy consumption for non-qualified product
$kWh_{EE}$ = Average unit energy consumption for ENERGY STAR® qualified product

## Baseline Efficiency

The baseline efficiency case is a conventional standard sized non-ENERGY STAR® qualified model meeting Federal Standards energy performance metric criteria effective January 1, 2010 for dishwashers with maximum energy consumption of less than or equal to 355 kWh/year and maximum water consumption of 6.5 gallons of water/cycle.[203]

## High Efficiency

The high efficiency case is an ENERGY STAR® qualified standard sized dishwasher meeting the energy performance metric criteria effective July 1, 2011 for dishwashers with maximum energy consumption of greater than or equal to 307 kWh/year and maximum water consumption of 5.0 gallons/cycle.

[201] Source for these values is the 9/7/09 version of the energystar.gov appliance calculator using 1/1/10 Federal Standard for baseline consumption.
[202] Ibid.
[203] Home: ENERGY STAR (2010). *Dishwasher Key Product Criteria.* http://www.energystar.gov/index.cfm?c=dishwash.pr_crit_dishwashers. Accessed on 10/20/10.

### Hours

Dishwashers are assumed to run 215 cycles per year.[204]

### Measure Life

The measure life is 10 years.[205]

### Secondary Energy Impacts

Gas, Oil and Propane savings occur in homes where the water is heated by that fuel.[206]

| Program | Natural Gas Savings (MMBtu/unit) | Oil Savings (MMBtu/unit) | Propane Savings (MMBtu/unit) |
|---|---|---|---|
| RNC | 0.0714 | 0.002 | 0.0041 |
| LI RNC | 0.1035 | 0.0002 | 0.0096 |

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Residential Water | Reduction in annual water usage compared to conventional unit[207] | 430 Gallons/Unit | |
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[208] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Dishwasher | RNC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.89 | 1.00 |
| Dishwasher | LI RNC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.91 | 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**
Coincidence factors are based on Massachusetts Common Assumptions.

[204] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Residential Dishwasher*. Interactive Excel Spreadsheet found at http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls
[205] Ibid.
[206] Ibid.
[207] Ibid.
[208] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*

# Hot Water – Pool Pump

### 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**: Hot Water
**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
ΔkW = Average annual kW reduction: 0.071 kW[209]
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[210]

### Baseline Efficiency

The baseline efficiency case is a single speed pump.

### 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.

[209] Quantec (2001). *National Grid Demand Impact Template.* Interactive spreadsheet tool developed for National Grid.
[210] Davis Energy Group (2008). *Proposal Information Template for Residential Pool Pump Measure Revisions*. Prepared for Pacific Gas and Electric Company; Page 2.

### Measure Life

The measure life is 10 years.[211]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Pool Pumps | ES Appliances | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.30 | 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**
Coincidence factors are based on Massachusetts Common Assumptions.

[211] Davis Energy Group (2008). *Proposal Information Template for Residential Pool Pump Measure Revisions*. Prepared for Pacific Gas and Electric Company.

# Hot Water – Waterbed Mattress Replacement

### Measure Overview

**Description:** Replacement of waterbed mattress with a standard mattress.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** Annual Discounted Rate Cost Reduction
**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 | = | Mattress replacement |
| ΔkWh | = | Average annual kWh reduction: 872 kWh[212] |
| ΔkW | = | Average annual kW reduction: 0.109 kW[213] |

### 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.

### Measure Life

The measure life is 10 years.[214]

[212] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.
[213] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[214] 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).

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[215] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Waterbed | LI 1-4 Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.75 | 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 2000 EnergyWise program impact evaluation.[216]

[215] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[216] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# MassSAVE – Vendor Measures

### Measure Overview

**Description:** Retrofit measures installed through the MassSAVE program including: building envelope insulation and air sealing, duct sealing and insulation, programmable thermostats, heating system replacement, windows and DHW measures.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** Gas, Oil, Propane
**Non-Energy Impact:** Water
**Sector:** Residential
**Market:** Retrofit
**End Use:** HVAC, Hot Water
**Program:** MassSAVE

### Algorithms for Calculating Primary Energy Impact

National Grid uses vendor calculated savings for these measures in the Residential MassSAVE 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.

### 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.

### Measure Life

| Measure Name | Measure Life (years) |
|---|---|
| Air Sealing | 15 |
| DHW ISMs | 7 |
| Duct Insulation | 20 |
| Duct Seal | 20 |
| Heating System Replacement | 18 |
| Indirect Water Heater | 20 |
| Insulation | 25 |
| Thermostats | 10 |
| Windows | 25 |

### Secondary Energy Impacts

Gas, Oil and Propane savings are project-specific.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Residential Water | Residential water savings for DHW measures[217] | 8785 Gallons /Participant | DHW ISMs only |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Air Sealing (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.72 | 0.28 |
| Air Sealing (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| DHW ISMs (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.75 | 1.00 |
| DHW ISMs (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Duct Insulation (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.72 | 0.28 |
| Duct Insulation (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| Duct Sealing (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.72 | 0.28 |
| Duct Sealing (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| Heating System Replacement (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Indirect Water Heater (Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Insulation (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.72 | 0.28 |
| Insulation (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| Thermostats (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.03 | 1.00 |
| Thermostats (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Windows (Electric) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.30 |
| Windows (Gas, Oil, Other FF) | MassSAVE | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |

[217] ACEEE 7th Ed (1999). *Consumer Guide to Home Energy Savings;* Page 133, multiplied by 0.6275 to account for MECo (Massachusetts Electric Co) territory family size-2000 US Census data.

**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**
Coincidence factors are based on Massachusetts Common Assumptions.

# Multifamily – Insulation (Walls, Roof, Floor)

### Measure Overview

**Description:** Insulation upgrades are applied in existing facilities.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact**: Low Income Only: Annual Discounted Rate Cost Reduction, Annual Fire, Illness and Moving Avoidance Benefits, One-Time Property Value Benefit
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** HVAC
**Program:** Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

$$\Delta kWh = SQFT \times kWh / SQFT \times \left( \frac{1}{R-VALUE_{BASE}} - \frac{1}{R-VALUE_{EE}} \right)$$

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

Where:

| | | |
|---|---|---|
| SQFT | = | Square feet of insulation installed |
| $R\text{-}VALUE_{BASE}$ | = | R-Value of the existing insulation |
| $R\text{-}VALUE_{EE}$ | = | R-Value of the new installed insulation |
| kWh/SQFT | = | Average annual kWh reduction per SQFT of insulation. See Table below. |
| kW/kWh | = | Average annual kW reduction per kWh reduction: 0.000125 kW/kWh[218] |

| Insulation Type | kWh/Sqft[219] |
|---|---|
| Basement | 10.62 |
| Attic | 38.803 |
| WALL (N, S) | 11.477 |
| WALL (W, E) | 10.025 |

### 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.

[218] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[219] National Grid's Multifamily Screening Tool. This was developed in the early 1990's. Documentation of the specific variables is unavailable. Evaluation results have consistently shown realization rates close to 100%.

### Measure Life

The measure life is 25 years.[220]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure

### Non-Energy Benefits

| Benefit Type | Description | Savings[221] | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction | $(R1-R2)/kWh | Low Income |
| Annual Non-Resource | Annual Fire, Illness and Moving Avoidance Benefits | $203/Participant | Low Income |
| One-Time Non-Resource | The One-Time Property Value Benefit | $20.70 x $Cost/kWh x kWh Saved | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Insulation (Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.03 | 1.00 |
| Insulation (Non-Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.03 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[222]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[223]

[220] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[221] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[222] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[223] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Multifamily – DHW (Showerheads and Aerators)

### Measure Overview

**Description:** An existing showerhead or aerator with a high flow rate is replaced with a new low flow showerhead or aerator.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** Residential Water, Low Income Only: Annual Discounted Rate Cost Reduction
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** Hot Water
**Program:** Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

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

| | | |
|---|---|---|
| Unit | = | Showerhead or aerator installation. |
| ΔkWh | = | Average annual kWh reduction per unit: 80.3 kWh[224] |
| kW/kWh | = | Average kW reduction per kWh reduction: 0.000125 kW/kWh[225] |

### Baseline Efficiency

The baseline efficiency case is an existing shower head or faucet aerator with a high flow.

### High Efficiency

High efficiency is a low flow showerhead or faucet aerator.

### Hours

Not applicable.

### Measure Life

The measure life is 7 years.[226]

[224] National Grid's Multifamily Screening Tool. This was developed in the early 1990's. Documentation of the specific variables is unavailable. Evaluation results have consistently shown realization rates close to 100%.
[225] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[226] Massachusetts Common Assumption.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Benefits

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Residential Water | Gallons water saved per year per unit that received DHW measures[227] | 8785 Gallons/Participant | |
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[228] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Showerhead/Aerator (Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.75 | 1.00 |
| Showerhead/Aerator (Non-Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.75 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[229]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[230]

[227] ACEEE 7th Ed (1999). *Consumer Guide to Home Energy Savings;* Page 133, multiplied by 0.6275 to account for MECo (Massachusetts Electric Co) territory family size-2000 US Census data.
[228] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[229] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[230] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Multifamily – DHW (Tank and Pipe Wrap)

### Measure Overview

**Description:** A wrap is added to the water heater tank or pipes.
**Primary Energy** Impact: Electric
**Secondary Energy** Impact: None
**Non-Energy Impact**: Low Income Only: Annual Discounted Rate Cost Reduction
**Sector**: Residential, Low Income
**Market**: Retrofit
**End Use**: Hot Water
**Program:** Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

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

Where:

| | | |
|---|---|---|
| Unit | = | Each installation for tank wraps, per linear foot for pipe wrap. |
| kWh | = | Average annual kWh reduction per unit: 55 kWh[231] |
| kW/kWh | = | Average annual kW reduction per kWh reduction: 0.000125 kW/kWh[232] |

### Baseline Efficiency

The baseline efficiency case is no wrap on the tank or pipes.

### High Efficiency

High efficiency is the addition of a wrap.

### Hours

Not applicable.

### Measure Life

The measure life is 7 years.[233]

### Secondary-Energy Impacts

There are no secondary energy impacts for this measure.

[231] National Grid's Multifamily Screening Tool. This was developed in the early 1990's. Documentation of the specific variables is unavailable. Evaluation results have consistently shown realization rates close to 100%.
[232] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[233] Massachusetts Common Assumption

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction [234] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Tank/Pipe Wrap (Electric Heat) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.75 | 1.00 |
| Tank/Pipe Wrap (Non-Electric Heat) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.75 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[235]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[236]

[234] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[235] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[236] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Multifamily – Thermostats

### Measure Overview

**Description:** Installation of programmable thermostats
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** Low Income Only: Annual Discounted Rate Cost Reduction
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** HVAC
**Program:** Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

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

Where:

| | | |
|---|---|---|
| Unit | = | Installation of programmable thermostat. |
| ΔkWh | = | Average annual kWh reduction per unit: 288 kWh[237] |
| kW/kWh | = | Average annual kW reduction per kWh reduction: 0.000125 kW/kWh[238] |

### 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 thermostats and fixed set point (common areas) thermostats.

### Hours

Not applicable.

### Measure Life

The measure life is 10 years.[239]

[237] National Grid's Multifamily Screening Tool. This was developed in the early 1990's. Documentation of the specific variables is unavailable. Evaluation results have consistently shown realization rates close to 100%.
[238] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[239] 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 | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction [240] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Thermostat (Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.03 | 1.00 |
| Thermostat (Non-Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.03 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[241]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[242]

[240] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[241] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[242] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Multifamily – Heat Pump Tune-Up

### Measure Overview

**Description:** Heat pump tune-up for electrically-heated homes only.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** Low Income Only: Annual Discounted Rate Cost Reduction
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** HVAC
**Program:** Multi-Family Retrofit

### 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 | = | Heat pump tune-up performed |
| ΔkWh | = | Average annual kWh reduction per unit: 1162 kWh[243] |
| kW/kWh | = | Average kW reduction per kWh reduction: 0.000125 kW/kWh[244] |

### 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.

### Measure Life

The measure life is 5 years.[245]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[243] National Grid's Multifamily Screening Tool. This was developed in the early 1990's. Documentation of the specific variables is unavailable. Evaluation results have consistently shown realization rates close to 100%.
[244] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[245] Massachusetts Common Assumption

### Non-Energy Benefits

There are no non-energy benefits for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Heat Pump Tune-up (Electric) | MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.03 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[246]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[247]

[246] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[247] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Multifamily – Air Sealing

### Measure Overview

**Description:** Thermal shell air leaks are sealed through strategic use and location of air-tight materials.
**Primary Energy Impact**: Electric
**Secondary Energy Impact**: None
**Non-Energy Impact**: Low Income Only: Annual Discounted Rate Cost Reduction
**Sector**: Residential, Low Income
**Market**: Retrofit
**End Use**: HVAC
**Program**: Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = Stories \times SQFT \times \left(CFM / SQFT_{PRE} - CFM / SQFT_{POST}\right) \times \Delta kWh / CFM$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

| | | |
|---|---|---|
| Stories | = | Total stories in the multi-family building |
| SQFT | = | Total SQFT of building |
| $CFM/SQFT_{PRE}$ | = | Estimate of pre-retrofit air leakage in CFM/SQFT based on number of stories in the building and air-tightness ratings of the existing roof and floor. |
| $CFM/SQFT_{POST}$ | = | Estimate of post-retrofit air leakage in CFM/SQFT based on number of stories in the building and air-tightness ratings of the improved roof and floor. |
| ΔkWh/CFM | = | Average annual kWh reduction per CFM: 2.48633 kWh/CFM[248] |
| kW/kWh | = | Average kW reduction per kWh reduction: 0.000125 kW/kWh[249] |

### 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.

[248] National Grid's Multifamily Screening Tool. This was developed in the early 1990's. Documentation of the specific variables is unavailable. Evaluation results have consistently shown realization rates close to 100%.
[249] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.

### Measure Life

The measure life is 15 years.[250]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Benefits

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction[251] | $(R1-R2)/kWh | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Air Sealing (Electric Heat) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.03 | 1.00 |
| Air Sealing (Non-Electric Heat) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.03 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[252]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[253]

[250] GDS Associates, Inc. (2007). *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for The New England State Program Working Group.
[251] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[252] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[253] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# Multifamily – Refrigerators and Freezers

### 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:** Low Income Only: Annual Discounted Rate Cost Reduction, One-Time Avoided Refrigerator Purchase
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** Refrigeration
**Program:** Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = kWh_{PRE} - kWh_{POST}$$
$$\Delta kW = \Delta kWh \times kW / kWh$$

Where:

| | | |
|---|---|---|
| Unit | = | Replacement of existing refrigerator with new ENERGY STAR® refrigerator |
| $kWh_{PRE}$ | = | Annual kWh consumption of existing equipment. Value entered by the user. |
| $kWh_{POST}$ | = | Annual kWh consumption of new installed equipment. Value entered by the user. |
| kW/kWh | = | Average kW reduction per kWh reduction: 0.00013 kW/kWh[254] |

### 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 for non low income[255] and 19 years for low income.[256]

[254] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[255] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Residential Refrigerator.* Interactive Excel Spreadsheet found at www.energystar.gov/.../business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls.
[256] Massachusetts Common Assumption.

### Hours

Not applicable.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction [257] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource | One-Time Avoided Refrigerator Purchase [258] | $200/Unit | |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Refrig/Freezers (Electric Heat) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 1.00 | 0.92 |
| Refrig/Freezers (Non-Electric Heat) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 0.92 |

**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 from the National Grid Energy Wise 2008 Program Evaluation.[259]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[260]

[257] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[258] Ibid...
[259] Cadmus Group (2010). *EnergyWise 2008 Program Evaluation.* Prepared for National Grid.
[260] Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program*. Prepared for National Grid.

# MultiFamily – Fixtures and CFLs

### 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:** O&M, Low Income Only: Annual Discounted Rate Cost Reduction
**Sector:** Residential, Low Income
**Market:** Retrofit
**End Use:** Lighting
**Program:** Multi-Family Retrofit, Low-Income MultiFamily Retrofit

### Algorithms for Calculating Primary Energy Impact

Unit savings are calculated using the following algorithms and assumptions:

$$\Delta kWh = [(QTY_{PRE} \times Watts_{PRE} \times Hours_{PRE}) - (QTY_{EE} \times Watts_{EE} \times Hours_{EE})]/1000 \times 52$$
$$\Delta kW = [(QTY_{PRE} \times Watts_{PRE}) - (QTY_{EE} \times Watts_{EE})]/1000$$

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 |

### Baseline Efficiency

The baseline efficiency case is the existing fixture and bulbs.

### High Efficiency

The high efficiency case is the new fixture and lamps.

### Measure Life

The measure life is 7 years for CFLs and 20 years for fixtures.

### 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 | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction [261] | $(R1-R2)/kWh | Low Income |
| One-Time Non-Resource (CFL) | O&M Cost Reduction [262] | $3.00/Bulb | |
| One-Time Non-Resource (Fixture) | O&M Cost Reduction [263] | $3.50/Fixture | |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CFLs (Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.35 | 1.00 |
| CFLs (Non-Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.35 | 1.00 |
| Fixtures (Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.91 | 0.91 | 0.91 | 0.35 | 1.00 |
| Fixtures (Non-Electric) | MF Retrofit, LI MF Retrofit | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.35 | 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 from the National Grid Energy Wise 2008 Program Evaluation.[264]

**Coincidence Factors**
Summer and winter coincidence factors are estimated using demand allocation methodology described National Grid 2000 EnergyWise impact evaluation.[265]

[261] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[262] MA Electric Utilities (2003). *Non-Electric Benefit Performance Metrics – Residential 1.* Memo to MA non-Electric Parties.
[263] Ibid.
[264] Cadmus Group (2010). EnergyWise 2008 Program Evaluation. Prepared for National Grid.
[265] Quantec, LLC (2000). Impact Evaluation: Single-Family EnergyWise Program. Prepared for National Grid.

# Behavior – OPOWER Electric

### Measure Overview

**Description:** The OPOWER program sends energy use reports to participating electric customers in order to change customers' energy-use behavior. In 2010, the program was planned with only one measure for all participant cohorts. In 2011, the program was planned with unique measures for each participant cohort. In 2011, the program's name was changed to Behavior/Feedback.
**Primary Energy Impact**: Electric
**Secondary Energy Impact**: None
**Non-Energy Impact**: None
**Sector**: Residential
**Market**: Products and Services
**End Use**: Behavior
**Program**: OPOWER Program

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta kWh = (kWh_{BASE})(\%SAVE)$$
$$\Delta kW = \Delta kWh / 4000$$

Where:
Unit = One participant household
$kWh_{BASE}$ = Baseline consumption of kWh. See Table below.
$\%SAVE_{kWh}$ = Energy savings percent per program participant. See Table below.

**OPOWER Program - Electric Savings Factors**[266]

| Measure Name | $kWh_{BASE}$ | %SAVE | ΔkWh/Unit | ΔkW/Unit |
|---|---|---|---|---|
| CUSTSERV | 13,017 | 1.61% | 209.58 | 0.052 |

### Baseline Efficiency

The baseline efficiency case is a customer who does not receive OPOWER Behavior/Feedback program reports.

### High Efficiency

The high efficiency case is a customer who receives an OPOWER Behavior/Feedback program report.

### Hours

Not applicable.

[266] ODC and Navigant (2011). *MA Cross-Cutting Behavioral Program Evaluation.* Prepared for Massachusetts Energy Efficiency Advisory Council. Study 17 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.

### 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.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CUSTSERV | OPOWER | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.25 | 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

**Coincidence Factors**
Coincidence Factors are based on evaluation results. [267]

[267] Ibid.

# Commercial and Industrial Electric Efficiency Measures

# Lighting – Advanced Lighting Design (Performance Lighting)

### 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

$$\Delta kWh = \sum_{i=1}^{n}\left(\frac{Watts_{BASE,i} - Watts_{EE,i}}{1000}\right)(Area_i)(Hours_i)$$

$$\Delta kW = \sum_{i=1}^{n}\left(\frac{Watts_{BASE,i} - Watts_{EE,i}}{1000}\right)(Area_i)$$

Where:

| | | |
|---|---|---|
| N | = | Total number of spaces in Space-by-Space Method or 1 for Building Area Method |
| $Watts_{BASE,i}$ | = | Allowed lighting wattage per square foot based on energy code requirements for building or space type *i*. For values, see Appendix A: Table 16 and Appendix A: Table 17. |
| $Watts_{EE,i}$ | = | Installed lighting wattage per square foot of the efficient lighting system for building or space type *i* |
| 1000 | = | Conversion factor: 1000 watts per 1 kW |
| $Area_i$ | = | Area of building or space *i* in square feet |
| $Hours_i$ | = | Annual hours of operation of the lighting equipment for building or space type *i* |

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 offers one compliance path, the Building Area Method. ASHRAE 90.1-2007 offers two compliance paths. For completeness, the lighting power density requirements for both the Building Area Method and

the Space-by-Space Method are presented.[268] Table 16 and Table 17 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.

**Hours**

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis.

**Measure Life**

| Measure | Measure Life [269] |
|---|---|
| Fluorescent Fixture | 15 years |
| Hardwired CFL | 15 years |
| LED Exit Signs | 15 years |
| HID (interior and exterior) | 15 years |

**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[270] |
|---|---|---|
| Interior Lighting | C&I Gas Heat | -0.0003649 MMBtu/ΔkWh |
| Interior Lighting | Oil | -0.0007129 MMBtu/ΔkWh |

**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 Table 20 for values.

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual O&M dollars saved due to avoided incandescent bulbs and labor | $OM/Fixture | CFL Fixtures only |

[268] 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.
[269] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[270] Optimal Energy, Inc. (2008). Non-Electric Benefits Analysis Update. Memo Prepared for NSTAR.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| All | NC | 1.00 | 1.00 | 1.07 | 0.80 | 0.73 | custom | custom |

**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**
Energy and demand RRs derived from impact evaluation of National Grid 2008 custom lighting installations[271]; final realization rates developed in 2008 custom program analysis study.[272]

**Coincidence Factors**
CFs are custom calculated based on site-specific information.

[271] KEMA, Inc. (2009). *National Grid USA 2008 Custom Lighting Impact Evaluation, Final Report*. Prepared for National Grid.
[272] KEMA, Inc. (2009). Sample *Design and Impact Evaluation Analysis of the 2008 Custom Program*. Prepared for National Grid; Table 19.

# Lighting – Lighting Systems

### 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.

### Baseline Efficiency

For large 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.[273] For lost opportunity installations, the baseline efficiency case is determined using assumed baseline wattages for each of the installed fixtures.[274] Small retrofit installations use the exact wattages and fixture counts from the existing space.

[273] MassSave (2010). *C&I Retrofit Lighting Wattage Tables.*
[274] MassSave (2010). *C&I New Construction Lighting Baseline Wattage Tables.*

### High Efficiency

For both large 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.[275] Small retrofit installations use the exact wattages and fixture counts from the existing space.

### Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis.

### Measure Life

| Equipment Type | Measure Life[276] | |
|---|---|---|
| | Retrofit | Lost Opportunity |
| Bulb – CFL screw base | 5 years | N/A |
| Fluorescent Fixture | 13 years | 15 years |
| Hardwired CFL | 13 years | 15 years |
| HID (interior and exterior) | 13 years | 15 years |
| LED Lighting Fixtures | 13 years | 15 years |
| LED Integral Replacement Lamps | 13 years | 15 years |
| LED Low Bay – Garage & Canopy Fixtures | 13 years | 15 years |

### 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 | Savings[277] |
|---|---|---|
| Interior Lighting | C&I Gas Heat | -0.0003649 MMBtu/kWh |
| Interior Lighting | Oil | -0.0007129 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 Table 20 for values.

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual O&M dollars saved due to avoided incandescent bulbs and labor | $OM/Fixture | |

[275] MassSave (2010). *C&I New Construction Lighting Wattage Tables* AND MassSave (2010). *C&I Retrofit Lighting Wattage Tables.*
[276] 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 Measures*. Prepared for The New England State Program Working Group; Table 2
[277] Optimal Energy, Inc. (2008). Non-Electric Benefits Analysis Update. Memo Prepared for NSTAR.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| All | NC | 1.00 | 1.00 | 1.02 | 0.97 | 0.97 | 0.98 | 0.73 |
| All | Large Retrofit | 1.00 | 1.00 | 1.04 | 1.03 | 1.03 | 0.89 | 0.63 |
| Screw-in CFLs | Small Retrofit | 1.00 | 0.87 | 1.08 | 0.99 | 0.99 | 0.79 | 0.39 |
| All (except screw in CFLs) | Small Retrofit | 1.00 | 1.00 | 1.08 | 0.99 | 0.99 | 0.79 | 0.39 |

**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: 0.874 for screw-in CFLs installed through the C&I Small Retrofit program based on 1996 savings persistence study.[278]

**Realization Rates**

*New Construction & Major Renovation Commercial*
- Energy and demand RRs from impact evaluation of National Grid's 2007 Design 2000plus (New Construction) Lighting installations.[279] Demand RR is the connected demand RR; energy RR includes connected demand RR, hours of use RR and HVAC Interactive adjustment.

*C&I Large Retrofit*
- Energy RR is from impact evaluation of National Grid's 2007 Energy Initiative (Large Retrofit) Lighting program.[280] Energy RR is the ratio measured electric energy savings to gross estimates of electric energy savings, and includes electric HVAC interaction adjustment by default. Demand RRs are from impact evaluation of National Grid's 2003 Energy Initiative Lighting program.[281] Demand RR is the connected demand RR.

*C&I Small Retrofit*
- Energy RRs from statewide impact evaluation of 2010 Small Business Services programs.[282]
- Demand RRs are connected demand RRs, from statewide impact evaluation of 2010 Small Business Services programs.[283]

**Coincidence Factors**

*New Construction & Major Renovation Commercial*
Coincidence Factors are based on a study of National Grid's 2007 Design 2000*plus* Lighting subprogram.[284] Lighting coincidence factors include HVAC interactive effects.

*C&I Large Retrofit*

[278] HEC, Inc. (1996). Final Report for New England Power Service Company Persistence of Savings Study. Prepared for NEPSCo.
[279] KEMA (2009). *Design 2000plus Lighting Hours of Use and Load Shape Measurement Study.* Prepared for National Grid.
[280] Summit Blue Consulting, LLC. (2008). Large *Commercial and Industrial Retrofit Program Impact Evaluation 2007*. Prepared for National Grid.
[281] RLW Analytics (2004). *2003 Energy Initiative "EI" Lighting Impact Evaluation Final Report*. Prepared for National Grid.
[282] The Cadmus Group, ERS. (2011). *Non-Controls Lighting Evaluation for the Massachusetts Small Commercial Direct Install Program - Fourth Draft*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council. Study 19 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.
[283] Ibid.
[284] KEMA, Inc. (2009). *Design 2000plus Lighting Hours of Use and Load Shapes Measurement Study*. Prepared for National Grid.

Lighting coincidence Factors are based on a NEEP regional C&I Lighting Loadshape study. Coincidence factors include HVAC interactive effects.[285]

*C&I Small Retrofit*
Summer Coincidence Factor is based on a NEEP regional C&I Lighting Loadshape study.[286] Winter Coincidence Factor is based on statewide impact evaluation of the 2010 Small Business Services programs.[287] Coincidence factors include HVAC interactive effects.

[285] KEMA, Inc. (2011). *C&I Lighting Loadshape Project*. Prepared for NEEP Regional EM&V Forum. Study 32 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.
[286] Ibid.
[287] The Cadmus Group, ERS. (2011). *Non-Controls Lighting Evaluation for the Massachusetts Small Commercial Direct Install Program - Fourth Draft*. Prepared for Massachusetts Joint Utilities. Study 19 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.

# Lighting – Lighting Controls

### 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

$$\Delta kWh = (Controlled\ kW)(Hours_{BASE} - Hours_{EE})$$
$$\Delta kW = (Controlled\ kW)$$

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.

### Baseline Efficiency

The baseline efficiency case assumes no controls (retrofit) or code-compliant controls (new construction).

### High Efficiency

The high efficiency case involves lighting fixtures connected to controls that reduce the pre-retrofit or baseline hours of operation.

### Hours

The annual hours of reduction for lighting controls are site-specific and should be determined on a case-by-case basis.

### Measure Life

| Measure | Measure Life[288] | |
|---|---|---|
| | Retrofit | Lost Opportunity |
| Occupancy Sensors | 9 years | 10 years |
| Daylight Dimming | 9 years | 10 years |

### Secondary Energy Impacts

Heating energy will be increased due to reduced lighting waste heat.

| Measure | Energy Type | Savings[289] |
|---|---|---|
| Interior Lighting | C&I Gas Heat | -0.0003649 MMBtu/kWh |
| Interior Lighting | Oil | -0.0007129 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 Table 20 for values.

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual O&M dollars saved due to avoided incandescent bulbs and labor | $OM/Fixture | CFL Fixtures only |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Occupancy Sensors | NC, Large Retrofit | 1.00 | 1.00 | 0.76 | 0.96 | 0.96 | 0.30 | 0.19 |
| Daylight Dimming | NC, Large Retrofit | 1.00 | 1.00 | 0.38 | 0.96 | 0.96 | 0.15 | 0 |
| Occupancy Sensors | Small Retrofit | 1.00 | 1.00 | 0.87 | 0.94 | 0.94 | 0.35 | 0.28 |

**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 from National Grid impact evaluation of C&I lighting controls installations.[290]

[288] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1
[289] Optimal Energy, Inc. (2008). *Non-Electric Benefits Analysis Update*. Memo Prepared for NSTAR.
[290] RLW Analytics (2007). *Lighting Controls Impact Evaluation Final Report, 2005 Energy Initiative, Design 2000plus and Small Business Services Program.* Prepared for National Grid.

**Coincidence Factors**

CFs from National Grid impact evaluation C&I lighting controls installations.[291]

[291] Ibid.

# Lighting – Freezer/Cooler LEDs

### 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 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:

| | | |
|---|---|---|
| $\Delta kWh_{LED}$ | = | Reduction in lighting energy |
| $\Delta kWh_{Heat}$ | = | Reduction in refrigeration energy due to reduced heat loss from the lighting fixtures |
| N | = | Total number of lighting fixture types in the pre-retrofit case |
| M | = | Total number of lighting fixture types in the post-retrofit case |
| $Count_i$ | = | 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: 1.3 kW/ton[292] |

### Baseline Efficiency

The baseline efficiency case is the existing lighting fixtures in the cooler or freezer cases.

[292] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation*. Prepared for National Grid.

### 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.[293]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Freezer/Cooler LEDs | Small Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.07 | 1.15 |

**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**
RRs for small retrofit installations based on impact evaluation of 2005 small retrofit custom measures.[294]

**Coincidence Factors**
CFs for small retrofit installations based on impact evaluation of 2005 small retrofit custom measures.[295]

[293] Energy & Resource Solutions (2005*). Measure Life Study*. Prepared for The Massachusetts Joint Utilities.
[294] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation*. Prepared for National Grid.
[295] Ibid.

# HVAC – Single-Package and Split System Unitary Air Conditioners

## 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:*

$$\Delta kWh = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{Cool})$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)$$

*For units with cooling capacities equal to or greater than 65 kBtu/h:*

$$\Delta kWh = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)(EFLH_{Cool})$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

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 1 for values. |
| $SEER_{EE}$ | = | Seasonal Energy Efficiency Ratio of the energy efficient equipment. |
| $EFLH_{Cool}$ | = | Cooling equivalent full load hours. See Hours section below. |
| $EER_{BASE}$ | = | Energy Efficiency Ratio of the baseline equipment. See Table 1 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.

**Baseline Efficiency**

Table 1 details the specific efficiency baselines by equipment type and capacity.

**Table 1: Unitary Air Conditioners Baseline Efficiency Levels**

| Equipment Type | Size Category | Subcategory or Rating Condition | Baseline Efficiency |
|---|---|---|---|
| Air conditioners, air cooled | <65,000 Btu/h | Split system and single system | 10 SEER |
| | ≥65,000 Btu/h and <135,000 Btu/h | Split system and single package | 8.92 EER |
| | ≥135,000 Btu/h | Split system and single package | 8.6 EER |
| Air conditioners, Water and evaporatively cooled | ≥240,000 Btu/h | Split system and single package | 9.5 EER |

**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**

National Grid uses 777 cooling hours for all units.[296]

**Measure Life**

The measure life is 15 years.[297]

**Secondary Energy Impacts**

There are no secondary energy impacts for this measure.

**Non-Energy Impacts**

There are no non-energy impacts for this measure.

[296] SAIC (1998). *Impact Evaluation of the Design 2000plus Unitary HVAC Program.* Prepared for National Grid.
[297] 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Unitary AC | NC | 1.00 | 1.00 | 1.25 | 0.90 | 1.00 | 0.44 | 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**
Energy and demand RR based on 2011 NEEP load shape study.[298]

**Coincidence Factors**
CFs from 1998 unitary HVAC study.[299]

[298] KEMA (2011). *C&I Unitary HVAC Load Shape Project Final Report.* Prepared for the Regional Evaluation, Measurement and Verification Forum. Study 33 in the 2010 Massachusetts Electric Energy Efficiency Annual Report. AND 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. RRs found as the ratio between EFLH reported in each study. RR calculated in order to maintain consistency with other PAs. New EFLHs from NEEP study to be used next year.
[299] SAIC (1998). *Impact Evaluation of the Design 2000plus Unitary HVAC Program.* Prepared for National Grid

# HVAC – Single Package or Split System Heat Pump Systems

## 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:*

$$\Delta kWh = (kBtu/h)\left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right)(EFLH_{COOL})(HF)$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

*For all water source, groundwater source, ground source units, and air cooled units with cooling capacities equal to, or greater than, 65 kBtu/h:*

$$\Delta kWh = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)(EFLH_{COOL})$$

$$\Delta kW = (kBtu/h)\left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

Where:

| | | |
|---|---|---|
| ΔkWh | = | Gross annual kWh savings from the measure. |
| kBtu/h[300] | = | Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h). |
| $SEER_{BASE}$ | = | Seasonal Energy Efficiency Ratio of the baseline equipment. See Baseline Efficiency section for values. |
| $SEER_{EE}$ | = | Seasonal Energy Efficiency Ratio of the energy efficient equipment. |
| $EFLH_{COOL}$ | = | Cooling mode equivalent full load hours. |
| HF | = | Heating Factor to account for savings in heating mode for air cooled heat pumps: 2.39[301] |

[300] For equipment with cooling capacities less than 65 kBtu/h, it is assumed that the heating capacity and cooling capacity are equal.

$EER_{BASE}$ = Energy Efficiency Ratio of the baseline equipment. See Baseline Efficiency section 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.

*Heating Capacity Conversion Factors:*

Air Source HPs
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**

National Grid specified 10 SEER for all air cooled heat pumps and 11.5 SEER for all water source heat pumps.

**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**

National Grid uses default hours of 777 hours[302] for air cooled heat pumps and 1029 hours[303] for water cooled heat pumps.

**Measure Life**

The measure life is 15 years.[304]

[301] 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
[302] SAIC (1998). *Impact Evaluation of the Design 2000plus Unitary HVAC Program.* Prepared for National Grid.
[303] 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
[304] 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Heat Pumps | NC | 1.00 | 1.00 | 1.25 | 0.90 | 1.00 | 0.44 | 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**
Energy and demand RR based on 2011 NEEP load shape study.[305]

**Coincidence Factors**
CFs from 1998 unitary HVAC study.[306]

[305] KEMA (2011). *C&I Unitary HVAC Load Shape Project Final Report.* Prepared for the Regional Evaluation, Measurement and Verification Forum. Study 33 in the 2010 Massachusetts Electric Energy Efficiency Annual Report. AND 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. RRs found as the ratio between EFLH reported in each study. RR calculated in order to maintain consistency with other PAs. New EFLHs from NEEP study to be used next year.
[306] SAIC (1998). *Impact Evaluation of the Design 2000plus Unitary HVAC Program.* Prepared for National Grid

# HVAC – Dual Enthalpy Economizer Controls (DEEC)

### 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[307]
$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.289 kW/ton[308]

### 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.

### Hours

Not applicable.

[307] Patel, Dinesh (2001). *Energy Analysis: Dual Enthalpy Control*. Prepared for NSTAR.
[308] Ibid.

### Measure Life

The measure life is 10 years for lost-opportunity applications.[309] The measure life is 7 years for retrofit installations.[310]

### 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| DEEC | NC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.40 | 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**
RRs are 1.0 since there have been no impact evaluations of the prescriptive savings calculations.

**Coincidence Factors**
CFs from 1998 unitary HVAC study.[311]

[309] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1
[310] 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.
[311] SAIC (1998). *Impact Evaluation of the Design 2000plus Unitary HVAC Program*. Prepared for National Grid

# HVAC – Demand Control Ventilation (DCV)

### Measure Overview

**Description:** The measure, offered through the CoolChoice program, is to control quantity of outside air to an air handling system based on detected space $CO_2$ levels. The installed systems monitor the $CO_2$ in the spaces or return air and reduce the outside air use when possible to save energy while meeting indoor air quality standards.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** Gas, Oil
**Non-Energy Impact**: None
**Sector:** Commercial & Industrial
**Market:** Lost Opportunity
**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
$SAVE_{kWh}$ = Average annual kWh reduction per ton of cooling capacity: 170 kWh/ton[312]
$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.15 kW/ton[313]

### Baseline Efficiency

The baseline efficiency case for this measure assumes the relevant HVAC equipment has no ventilation control.

### High Efficiency

The high efficiency case is the installation of an outside air intake control based on $CO_2$ sensors.

### Hours

The operating hours are site-specific for custom savings calculations.

### Measure Life

The measure life is 10 years.[314]

[312] Keena, Kevin (2008). *Analysis of CO2 Control Energy Savings on Unitary HVAC Units.* Prepared for National Grid.
[313] Ibid.

### Secondary Energy Impacts

Gas and oil heat impacts are counted for DCV measures for reduction in space heating. If these impacts are not custom calculated, they can be approximated using the interaction factors described below:

| Measure | Energy Type | Savings[315] |
|---|---|---|
| DCV | C&I Gas Heat | 0.001277 MMBtu/kWh |
| DCV | Oil | 0.002496 MMBtu/kWh |

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| DCV | NC | 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**
RRs based on engineering estimates.

**Coincidence Factors**
CFs based on engineering estimates.

[314] 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 Enthalpy Economizer.
[315] Optimal Energy, Inc. (2008). *Non-Electric Benefits Analysis Update*. Memo Prepared for NSTAR.

# HVAC – ECM Fan Motors

### 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 2 for values. |
| $\%Flow_{ANNUAL}$ | = | Average % of design flow over all operating hours. See Table 2 for values. |
| $\%Flow_{SP}$ | = | Average % of design flow during summer peak period. See Table 2 for values. |
| $\%Flow_{WP}$ | = | Average % of design flow during summer peak period. See Table 2 for values. |
| Hours | = | Annual operating hours for VAV box fans |

**Table 2: ECM Fan Motor Savings Factors** [316]

| 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.

[316] 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.[317]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| ECM Fan Motors | 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 all PAs programs include verification of equipment installations.

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

**Realization Rates**
RRs based on engineering estimates

**Coincidence Factors**
CFs based on engineering estimates.

[317] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

# HVAC – Energy Management System

### 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

### Algorithms for Calculating Primary Energy Impacts

Gross energy and demand savings for energy management systems (EMS) are custom calculated using National Grid's EMS savings calculation tools. The tool is used to calculate energy and demand savings based on project-specific details including hours of operation, HVAC system equipment and efficiency and points controlled.[318]

### 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.

### Measure Life

For lost-opportunity applications, the measure life is 15 years.[319] For retrofit applications, the measure life is 10 years.[320]

[318] Detailed descriptions of the EMS Savings Calculation Tools are included in the TRM Library under the "C&I Spreadsheet Tools" folder.
[319] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[320] Ibid.

### 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 | Savings[321] |
|---|---|---|
| EMS | C&I Gas Heat | 0.001277 MMBtu/ΔkWh |
| EMS | Oil | 0.002496 MMBtu/ΔkWh |

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| EMS | Large Retrofit | 1.00 | 1.00 | 1.04 | 1.03 | 1.03 | 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**
RRs derived from a 1994 study of HVAC and process cooling equipment.[322]

**Coincidence Factor**
CFs are custom calculated.

[321] Optimal Energy, Inc. (2008). *Non-Electric Benefits Analysis Update*. Memo Prepared for NSTAR.
[322] The Fleming Group (1994). *Persistence of Commercial/Industrial Non-Lighting Measures, Volume 3, Energy Management Control Systems*. Prepared for New England Power Service Company.

# HVAC – High Efficiency Chiller

## 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

*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:*

$$\Delta kWh = (Tons)(kW/ton_{BASE} - kW/ton_{EE})(Hours)$$

$$\Delta kW = (Tons)(kW/ton_{BASE} - kW/ton_{EE})(LF)$$

Where:

| | | |
|---|---|---|
| Tons | = | Rated capacity of the cooling equipment |
| $EER_{BASE}$ | = | Energy Efficiency Ratio of the baseline equipment. See Table 3 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 3 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 |

## Baseline Efficiency

The baseline efficiencies used in 2010 are a 10% reduction of the minimum efficiency requirements. Table 3 details the specific efficiency requirements and baseline efficiencies by equipment type and capacity.

**Table 3: Water Chilling Packages - Minimum Efficiency Requirements[323]**

| Equipment Type | Size Category (Tons) | Units | Minimum Efficiency | | Baseline Efficiency | |
|---|---|---|---|---|---|---|
| | | | Full Load | IPLV | Full Load | IPLV |
| Air-cooled chillers | < 150 | EER | 11.5 | 10.5 | 10.45 | 9.55 |
| Water cooled, electrically operated, positive displacement (rotary screw and scroll) | ≥ 75 and < 150 | kW/ton | 0.609 | 0.711 | 0.677 | 0.790 |
| | ≥ 150 and < 300 | kW/ton | 0.565 | 0.646 | 0.628 | 0.718 |
| | ≥ 300 | kW/ton | 0.515 | 0.575 | 0.572 | 0.639 |
| Water cooled, electrically operated, centrifugal | ≥ 150 and < 300 | kW/ton | 0.536 | 0.57 | 0.596 | 0.633 |
| | ≥ 300 and < 600 | kW/ton | 0.494 | 0.519 | 0.549 | 0.577 |

### 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

Hours are specified by equipment type as shown in the table below.[324]

| Equipment Type | Size Category (Tons) | EFLH | |
|---|---|---|---|
| | | Full Load | IPLV |
| Air-cooled chillers | < 150 | 698 | 698 |
| Water cooled, electrically operated, positive displacement (rotary screw and scroll) | ≥ 75 and < 150 | 1086 | 1038 |
| | ≥ 150 and < 300 | 1086 | 1038 |
| | ≥ 300 | 1620 | 2066 |
| Water cooled, electrically operated, centrifugal | ≥ 150 and < 300 | 1086 | 1038 |
| | ≥ 300 and < 600 | 1620 | 2066 |

### Measure Life

The measure life is 20 years.[325]

### Secondary Energy Impacts

There are no secondary energy impacts counted for this measure.

[323] DOE (2009). 2009 IECC Based Building Codes; Table 503.2.3(7): Water Chilling Packages, Efficiency Requirements - as of 1/1/2020 minimum efficiency values.
[324] Staff estimates from 1994.
[325] 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

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Chillers | NC | 1.00 | 1.00 | 1.04 | 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**
Energy RRs based on a 1994 study of HVAC and process cooling equipment.[326]

**Coincidence Factors**
CFs estimated based on 1993-1994 evaluation research and engineering estimates.

[326] 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.

# HVAC – Hotel Occupancy Sensors

### 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

### 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: 1801 kWh[327] |
| $SAVE_{kW}$ | = | Average annual kW reduction per unit: 0.35 kW[328] |

### 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.

### Hours

Not applicable.

### Measure Life

For retrofit applications, the measure life is 10 years.[329]

[327] MassSave (2010). *Energy Analysis: Hotel Guest Occupancy Sensors.*
[328] Ibid.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| HOS | Large Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.30 | 0.70 |

**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 based on engineering estimates.

**Coincidence Factors**
CFs based on engineering estimates.

[329] 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.

# HVAC – Programmable Thermostats

### 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 4.
$SAVE_{kW}$ = Average annual kWh reduction per SQFT of controlled. See Table 4.

**Table 4: Savings Factors (Save)[330]**

| 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.

### High Efficiency

The high efficiency case includes control of the space cooling and/or heating system as indicated in the equipment type selection.

[330] Factors form National Grid tracking system.

### Hours

Not applicable.

### Measure Life

For retrofit applications, the measure life is 8 years.[331]

### 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Thermostats | Small Retrofit | 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 PA programs include verification of equipment installations.

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

**Realization Rates**
RRs set to 100% based on no evaluations.

**Coincidence Factors**
CFs set to zero since no savings are expected during peak periods.

[331] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.

# Refrigeration – Door Heater Controls

### 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.[332]
**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[333]: 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 with the heaters operating at 80% (adjustable).[334]

### 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).

[332] The assumptions and algorithms used in this section are specific to NRM products.
[333] 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 (2004). *Cooler Control Measure Impact Spreadsheet User's Manual*. Prepared for NSTAR.
[334] Select Energy (2004). *Analysis of Cooler Control Energy Conservation Measures*. Prepared for NSTAR.

### Measure Life

The measure life for cooler and freezer door heater controls is 10 years.[335]

### 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Door Heater Control | Small Retrofit | 1.00 | 1.00 | 1.13 | 1.00 | 1.00 | 1.00 | 1.46 |

**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**
Energy RR based on staff estimates.

**Coincidence Factors**
CFs from the 1995 HEC study of walk-in cooler anti-sweat door heater controls.[336]

[335] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[336] HEC, Inc. (1995). *Analysis of Door Master Walk-In Cooler Anti-Sweat Door Heater Controls Installed at Ten Sites in Massachusetts*. Prepared for NEPSCo; Table 9.

# Refrigeration – Novelty Cooler Shutoff

### 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.[337]
**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[338] |
| HoursOFF | = | Potential hours off per night, estimated as one less than the number of hours the store is closed per day |
| $DC_{AVG}$ | = | Weighted average annual duty cycle[339] |

### 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.

### 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.

[337] The assumptions and algorithms used in this section are specific to NRM products.
[338] Conservative value based on 15 years of NRM field observations and experience.
[339] Ibid; the estimated duty cycles for Novelty Coolers are supported by Select Energy (2004). *Cooler Control Measure Impact Spreadsheet Users' Manual*. Prepared for NSTAR. The study gives a less conservative value than used by NRM.

### Measure Life

The measure life is 10 years.[340]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Novelty Cooler Shutoff | Small Retrofit | 1.00 | 1.00 | 1.13 | 1.00 | 1.00 | 0.73 | 1.46 |

**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**
Energy RR based on staff estimates.

**Coincidence Factors**
CFs from the 1995 HEC study of walk-in cooler anti-sweat door heater controls.[341]
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[340] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[341] HEC, Inc. (1995). *Analysis of Door Master Walk-In Cooler Anti-Sweat Door Heater Controls Installed at Ten Sites in Massachusetts*. Prepared for NEPSCo; Table 9.

# Refrigeration – ECM Evaporator Fan Motors for Walk–in Coolers and Freezers

### Measure Overview

**Description:** Installation of various sizes of electronically commutated motors (ECMs) in walk-in coolers and freezers to replace existing evaporator fan motors.[342]
**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

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Fan} = kW_{Fan} * LRF * Hours$$
$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / Hours$$

Where:

| | | |
|---|---|---|
| $\Delta kWh_{Fan}$ | = | Energy savings due to increased efficiency of evaporator fan motor |
| $\Delta kWh_{Heat}$ | = | Energy savings due to reduced heat from the evaporator fans |
| $kW_{Fan}$ | = | Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/adjustment[343] |
| LRF | = | Load reduction factor for motor replacement (65%)[344] |
| 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[345] |

### 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.

[342] The assumptions and algorithms used in this section are specific to NRM products.
[343] Conservative value based on 15 years of NRM field observations and experience.
[344] 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.
[345] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience.

### 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 = 35%[346] if the facility has evaporator fan controls. See section: Refrigeration – Evaporator Fan Controls for %OFF value.

### Measure Life

The measure life is 15 years.[347]

### 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Evap Fan ECMs | Small Retrofit | 1.00 | 1.00 | 1.61 | 1.00 | 1.00 | 1.50 | 0.70 |

**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**
RR based on 2005 custom small retrofit study.[348]

**Coincidence Factors**
CFs based on 2005 custom small retrofit study.[349]

[346] 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 (2004). *Cooler Control Measure Impact Spreadsheet User's Manual*. Prepared for NSTAR.
[347] ERS (2005). *Measure Life Study*. Prepared for The MA Joint Utilities; 15-year measure life for retrofit motor installations.
[348] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation.* Prepared for National Grid.
[349] Ibid.

# Refrigeration – Case Motor Replacement

### 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.[350]
**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

$$\Delta kWh = \Delta kWh_{Motor} + \Delta kWh_{Heat}$$
$$\Delta kWh_{motor} = kW_{Motor} * LRF * Hours$$
$$\Delta kWh_{heat} = \Delta kWh_{Motor} * 0.28 * Eff_{RS}$$
$$\Delta kW = \Delta kWh / Hours$$

Where:

| | | |
|---|---|---|
| $\Delta kWh_{Motor}$ | = | Energy savings due to increased efficiency of case motor |
| $\Delta kWh_{Heat}$ | = | Energy savings due to reduced heat from evaporator fans |
| $kW_{motor}$ | = | Metered load of case motor |
| LRF | = | Load reduction factor: 53% when shaded pole motors are replaced, 29% when PSC motors are replaced[351] |
| Hours | = | Average runtime of case motors (8,500 hours)[352] |
| 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) [353] |

### 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.

[350] The assumptions and algorithms used in this section are specific to NRM products.
[351] Load factor is an estimate by NRM based on several pre- and post-meter readings of installations
[352] Conservative value based on 15 years of NRM field observations and experience.
[353] Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience.

### Measure Life

The measure life is 15 years.[354]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Case ECMs | Small Retrofit | 1.00 | 1.00 | 1.61 | 1.00 | 1.00 | 1.50 | 0.70 |

**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**
RR based on 2005 custom small retrofit study.[355]

**Coincidence Factors**
CFs based on 2005 custom small retrofit study.[356]

[354] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.
[355] RLW Analytics (2007). *Small Business Services Custom Measure Impact Evaluation.* Prepared for National Grid.
[356] Ibid.

# Refrigeration – Evaporator Fan Controls

## 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.[357]
**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

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat} + \Delta kWh_{Control}$$
$$\Delta kWh_{Fan} = kW_{Fan} * 8760 * \%OFF$$
$$\Delta kWh_{Heat} = \Delta kWh_{Fan} * 0.28 * Eff_{RS}$$
$$\Delta kWh_{Control} = \left[kW_{CP} * Hours_{CP} + kW_{Fan} * 8760 * (1 - \%Off)\right] * 5\%$$
$$\Delta kW = \Delta kWh / 8760$$

Where:

| | | |
|---|---|---|
| $\Delta kWh_{Fan}$ | = | Energy savings due to evaporator being shut off |
| $\Delta kWh_{Heat}$ | = | Energy savings due to reduced heat from the evaporator fans |
| $\Delta kWh_{Control}$ | = | Energy savings due to the electronic controls on compressor and evaporator |
| $kW_{Fan}$ | = | Power demand of evaporator fan calculated from equipment nameplate data and estimated 0.55 power factor/adjustment[358] |
| %OFF | = | Percent of annual hours that the evaporator is turned off: 35%[359] |
| 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[360] |
| $kW_{CP}$ | = | Total power demand of compressor motor and condenser fan calculated from equipment nameplate data and estimated 0.85 power factor[361] |
| $Hours_{CP}$ | = | Equivalent annual full load hours of compressor operation[362] |
| 5% | = | Reduced run-time of compressor and evaporator due to electronic controls[363] |

[357] The assumptions and algorithms used in this section are specific to NRM products.
[358] Conservative value based on 15 years of NRM field observations and experience.
[359] 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 (2004). *Cooler Control Measure Impact Spreadsheet User's Manual*. Prepared for NSTAR.
[360] Estimated average refrigeration efficiency for small business customers.
[361] This value is an estimate by NRM based on hundreds of downloads of hours of use data form the electronic controller.
[362] Conservative value based on 15 years of NRM field observations and experience.
[363] Conservative estimate supported by less conservative values given by several utility-sponsored 3rd Party studies including: Select Energy (2004). *Analysis of Cooler Control Energy Conservation Measures*. Prepared for NSTAR.

### 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 35% from the 8,760 hours in the base case scenario.

### Measure Life

The measure life is 10 years.[364]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Evap Fan Control | Small Retrofit | 1.00 | 1.00 | 0.58 | 1.00 | 1.00 | 0.23 | 0.84 |

**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**
Small retrofit RRs from 1996 savings analysis[365]

**Coincidence Factors**
CFs from 1996 savings analysis[366]

[364] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[365] HEC, Inc. (1996), *Analysis of Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls*. Prepared for NEPSCo.
[366] Ibid.

# Refrigeration – Vending Misers

## 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 5 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 5 for values. |

**Table 5: Vending Machine and Cooler Controls Savings Factors**[367]

| Equipment Type | ΔkW | ΔkWh |
|---|---|---|
| Refrigerated Beverage Vending Machines | 0.1 | 800 |
| Non-Refrigerated Snack Vending Machines | 0 | 234 |
| Glass Front Refrigerated Coolers | 0.1 | 800 |

## 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.

[367] Deemed savings based on Staff estimates.

### 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.[368]

### 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Vending Misers | Large Retrofit | 1 | 1 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| Vending Misers | Small Retrofit | 1 | 1 | 1.035 | 1.004 | 1.12 | 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**
RRs calculated based the number and type of vending miser installations and results from 2006 RLW impact study.[369]

**Coincidence Factors**
CFs based on staff estimates.

[368] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[369] RLW (2007). *Small Business Service Custom Measure Impact Evaluation.* Prepared for National Grid.

# Compressed Air – High Efficiency Air Compressors

### 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 6 for values.
Hours = Annual operating hours of the air compressor.

**Table 6: Air Compressor kW Reduction per Horsepower**

| Control Type | Nominal Horsepower (HP) | kW Reduction per Horsepower (Save)[370] | |
|---|---|---|---|
| | | 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 |

### Baseline Efficiency

The baseline efficiency case is a typical modulating compressor with blow down valve.

[370] 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.

### 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.[371]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Air Compressor | NC, Large Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 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**
RRs based on impact evaluation of PY 2004 compressed air installations.[372]

**Coincidence Factors**
CFs based on impact evaluation of PY 2004 compressed air installations.[373]

[371] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[372] Ibid.
[373] Demand Management Institute (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

### 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 7.
Hours = Annual operating hours of the refrigerated air dryer.

**Table 7: Default kW Reduction per CFM by Dryer Capacity (*SAVE*)**

| Dryer Capacity ($CFM_{DRYER}$) | kW Reduction per CFM (Save)[374] |
|---|---|
| <100 | 0.00474 |
| ≥100 and <200 | 0.00359 |
| ≥200 and <300 | 0.00316 |
| ≥300 and <400 | 0.00290 |
| ≥400 | 0.00272 |

### 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.

[374] 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.

### Hours

The annual hours of operation for compressed air dryers are site-specific.

### Measure Life

The measure life is 15 years.[375]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Refrigerated Air Dryers | NC | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 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**
RRs based on impact evaluation of PY 2004 compressed air installations.[376]

**Coincidence Factors**
CFs based on impact evaluation of PY 2004 compressed air installations.[377]

[375] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-1.
[376] 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.*
[377] Ibid.

# Motors/Drives – Premium Efficiency Motors

### Measure Overview

**Description:** This measure promotes the purchase and installation of NEMA Premium Efficiency motors for new construction or time-of-replacement applications. Motors covered by this program must be new, three phase, induction motors, NEMA Design A & B, 1-200 HP, Open Drip-Proof (ODP) or Totally Enclosed Fan Cooled (TEFC), 1200, 1800, 3600 RPM and operate a minimum of 2,000 hours per year.
**Primary Energy Impact:** Electric
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**Sector:** Commercial & Industrial
**Market:** Lost Opportunity
**End Use**: Motors/Drives
**Program:** C&I New Construction & Major Renovation

### Algorithms for Calculating Energy and Demand Savings

$$\Delta kWh = (HP)(0.746)(LF)\left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ee}}\right)(HOURS)$$

$$\Delta kW = (HP)(0.746)(LF)\left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ee}}\right)$$

Where:

| | | |
|---|---|---|
| HP | = | Motor rated nameplate horsepower. |
| 0.746 | = | kW per HP. |
| LF | = | Motor load factor: 0.62[378] |
| $\eta_{base}$ | = | Baseline motor efficiency. See Table 18. |
| $\eta_{ee}$ | = | Installed motor efficiency. See Table 19. |
| HOURS | = | Motor annual run hours. |

### Baseline Efficiency

For both lost opportunity and retrofit applications, it is assumed that the baseline efficiency meets the minimum federal manufacturing requirements as legislated by the Energy Policy Act of 1992 (EPACT 1992). The Baseline Efficiency levels are presented in Appendix A: Table 18.

### High Efficiency

The high efficiency scenario assumes compliance with NEMA Premium Efficiency Motors requirements by motor type and size. These requirements are reproduced in Appendix A: Table 19.

[378] SAIC (1995). *Motor Run-Time and Persistence Study Final Report.* Prepared for New England Power Service Company; Exhibit 5.1.

### Hours

The annual hours of operation for motors are site-specific and should be determined on a case-by-case basis.

### Measure Life

The measure life is 20 years.[379]

### 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Motors | NC | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 | 0.76 | 0.60 |

**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**
Energy RR is the hours of use realization rate[380]; demand RR is set to 100% since the motor load factor is based on evaluated results.

**Coincidence Factors**
CFs from motor run-time and persistence study[381]

[379] Energy & Resource Solutions (2005). *Measure Life Study.* Prepared for The Massachusetts Joint Utilities; Table 1-1.
[380] SAIC (1995). *Motor Run-Time and Persistence Study Final Report.* Prepared for New England Power Service Company; Exhibit 5.1.
[381] Ibid.

# Motors/Drives – Variable Frequency Drives

### 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. 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

### Algorithms for Calculating Primary Energy Impacts

$$\Delta kWh = (HP)(kWh / HP)$$

$$\Delta kW = (HP)(kW / HP)$$

Where:
kWh/HP = Annual electric energy reduction based on program and equipment type. See Table 8.
kW/HP = Electric demand reduction based on program and equipment type. See Table 8.

**Table 8: VFD Savings Factors (kWh/HP and kW/HP)[382]**

| Measure | NEW CONSTRUCTION | | RETROFIT (Drive Only) | | RETROFIT (Motor & Drive) | |
|---|---|---|---|---|---|---|
| | Energy Savings Factors (kWh/HP) | Demand Savings Factors (kW/HP) | Energy Savings Factors (kWh/HP) | Demand Savings Factors (kW/HP) | Energy Savings Factors (kWh/HP) | Demand Savings Factors (kW/HP) |
| Building Exhaust Fan | 987.26 | 0.26 | 987.26 | 0.26 | 1039.78 | 0.27 |
| Boiler Feed Water Pump | 890.76 | 0.20 | 902.48 | 0.20 | 946.33 | 0.21 |
| Boiler Draft Fan | 1412.60 | 0.32 | 1438.39 | 0.32 | 1505.52 | 0.34 |
| Chilled Water Pump | 551.55 | 0.05 | 551.55 | 0.05 | 584.20 | 0.06 |
| Cooling Tower Fan | 295.80 | 0.06 | 843.25 | 0.11 | 861.52 | 0.12 |
| Heating Hot Water Pump | 969.13 | 0.25 | 969.13 | 0.25 | 1019.94 | 0.26 |
| Return Fan | 987.26 | 0.26 | 987.26 | 0.26 | 1039.78 | 0.27 |
| Supply Fan | 1443.02 | 0.31 | 1443.02 | 0.31 | 1511.08 | 0.32 |
| Make-Up Air Fan | 125.60 | 0.03 | 1160.65 | 0.23 | 1247.28 | 0.25 |
| Process Cooling Water Pump | 505.22 | 0.10 | 519.42 | 0.10 | 566.66 | 0.11 |
| WS Heat Pump Circulating Loop | 876.99 | 0.20 | 968.60 | 0.22 | 1224.11 | 0.28 |
| Waste Water Treatment Pump | N/A | N/A | 340.97 | 0.09 | 379.58 | 0.10 |

### Baseline Efficiency

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.

### 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.

### Measure Life

For lost-opportunity installations, the lifetime for this measure is 15 years. For retrofit projects, the lifetime is 13 years.[383]

### Secondary Energy Impacts

There are no secondary energy impacts.

[382] The estimates of gross savings were developed through spreadsheet models and historical participation information.
[383] 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 | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|---|
| VFD | NC | National Grid | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | **Error! Reference source not found.** | **Error! Reference source not found.** |
| VFD | Large Retrofit | National Grid | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | **Error! Reference source not found.** | **Error! Reference source not found.** |

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

**Savings Persistence Factor**
National Grid uses 100% savings persistence factors.

**Realization Rates**
RRs for all installations are set to 1.0.

**Coincidence Factors**
CFs vary by equipment type and program as given in Table 9.

**Table 9: Coincidence Factors for VSD Measures**

| Measure | NEW CONSTRUCTION | | RETROFIT Drive Only | | RETROFIT Motor & Drive | |
|---|---|---|---|---|---|---|
| | $CF_{SP}$ | $CF_{WP}$ | $CF_{SP}$ | $CF_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
| Building Exhaust Fan | 0.11 | 1.00 | 0.11 | 1.00 | 1.00 | 1.00 |
| Boiler Feed Water Pump | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| Boiler Draft Fan | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| Chilled Water Pump | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 |
| Cooling Tower Fan | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 |
| Heating Hot Water Pump | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| Return Fan | 0.11 | 1.00 | 0.11 | 1.00 | 1.00 | 1.00 |
| Supply Fan | 0.36 | 1.00 | 0.36 | 1.00 | 0.17 | 1.00 |
| Make-Up Air Fan | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Process Cooling Water Pump | 1.00 | 1.00 | 1.00 | 1.00 | 0.41 | 1.00 |
| WS Heat Pump Circulating Loop | 0.10 | 1.00 | 0.11 | 1.00 | 0.33 | 1.00 |
| Waste Water Treatment Pump | N/A | N/A | 1.00 | 1.00 | 1.00 | 1.00 |

# Custom Measures

### 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, 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.[384]

[384] Energy & Resource Solutions (2005). *Measure Life Study*. Prepared for The Massachusetts Joint Utilities; Table 1-2.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Comprehensive | NC, Large Retrofit, | 1.00 | 1.00 | 0.97 | 0.64 | 0.55 | custom | custom |
| Lighting | NC, Large Retrofit | 1.00 | 1.00 | 1.07 | 0.80 | 0.73 | custom | custom |
| HVAC | NC, Large Retrofit | 1.00 | 1.00 | 1.01 | 0.84 | 0.82 | custom | custom |
| Process | NC, Large Retrofit | 1.00 | 1.00 | 0.82 | 0.80 | 0.83 | custom | custom |
| CHP | NC, Large Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | custom | custom |
| Lighting | Small Retrofit | 1.00 | 1.00 | 1.04 | 1.07 | 1.15 | custom | custom |
| Refrigeration | Small Retrofit | 1.00 | 1.00 | 1.60 | 1.49 | 0.69 | custom | custom |
| Other | Small Retrofit | 1.00 | 1.00 | 0.81 | 0.77 | 0.53 | 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**

*C&I NC and C&I Large Retrofit*
- Realization Rates for the Lighting and Process categories are from "Sample Design and Impact Evaluation Analysis of the 2009 Custom Program".[385]
- Realization Rates for the Comprehensive and HVAC categories were updated based on the results of "Impact Evaluation of 2008-2009 Custom Comprehensive Installations"[386] and "Impact Evaluation of 2009 Custom HVAC Installations".[387] Both of these evaluations were performed by the Large C&I Evaluation Contractor team.
- Realization Rates for CHP projects are assumed to be 100% because projects undergo thorough technical review.

*C&I Small Retrofit:*
Realization Rates are derived from the results of an impact evaluation of National Grid's 2005 SBS program[388] and updated each year based on the distribution of 2010 installations.

**Coincidence Factors**

[385] KEMA, Inc. (2010). *Sample Design and Impact Evaluation Analysis of 2009 Custom Program.* Prepared for National Grid; Table 17.
[386] KEMA, Inc. and SBW (2011). *Impact Evaluation of 2008 and 2009 Custom Comprehensive Installations*. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council. Study 28 in the 2010 Massachusetts Electric Energy Efficiency Annual Report
[387] Ibid.
[388] RLW Analytics (2007). Small *Business Services Custom Measure Impact Evaluation*. Prepared for National Grid; Table 4.

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.

# Residential Natural Gas Efficiency Measures

# HVAC – Boiler (Forced Hot Water)

### Measure Overview

**Description**: Installation of a new space heating gas-fired boiler.
**Primary Energy Impact**: Natural Gas
**Secondary Energy Impact**: None
**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 = Installation of high efficiency boiler
ΔMMBtu = Annual MMBtu savings high efficiency boiler. See Table for values.

| Measure | ΔMMBtu/Unit |
|---|---|
| Boiler (AFUE >= 85%) | 7.2 [389] |
| Boiler (AFUE >= 90%) | 13.7 [390] |

### Baseline Efficiency

The baseline efficiency case is an 80% AFUE boiler.

### High Efficiency

The high efficiency case is a boiler with an AFUE of 85% or greater.

### Hours

Not applicable.

### Measure Life

The measure life is 20 years.[391]

[389] Nexus Market Research (2010). *HEHE Process and Impact Evaluation*. Prepared for GasNetworks.
[390] Ibid.
[391] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*. Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?c=boilers.pr_proc_boilers.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Boiler (AFUE >=85%) | Residential Heating and Water Heating | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Boiler (AFUE >=90%) | Residential Heating and Water Heating | 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 (Retrofit only)

### Measure Overview

**Description**: Boiler Reset Controls are devices that automatically control boiler water temperature based on outdoor temperature using a software program.
**Primary Energy Impact**: Natural Gas
**Secondary Energy Impact**: None
**Non-Energy Impact**: None
**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:
ΔMMBtu = Annual MMBtu savings per boiler reset control installed: 7.9 MMBtu[392]
Units = Number of installed Boiler Reset Controls

### 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.[393]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[392] ACEEE (2006). *Emerging Technologies Report: Advanced Boiler Controls*. Prepared for ACEEE; Page 2.
[393] Ibid.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Boiler Reset Controls | Residential Heating and Water Heating | 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 – Early Replacement Boiler

### Measure Overview

**Description**: Early retirement of inefficient gas-fired boiler and installation of new high efficiency gas-fired boiler.
**Primary Energy Impact**: Natural Gas
**Secondary Energy Impact**: None
**Non-Energy Impact**: None
**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 and include two parts: (1) energy savings over the remaining lifetime of the existing boiler and (2) energy savings over 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 new code-compliant boiler compared to existing boiler: 9.0 MMBtu[394] |
| $\Delta MMBtu_{EE}$ | = | Annual MMBtu savings of high efficiency boiler compared to new code-compliant boiler: 15.0 MMBtu[395] |

### Baseline Efficiency

For the retirement savings over the remaining life of existing boiler, the baseline is the existing inefficient boiler. For the high efficiency unit savings over lifetime of the new boiler, the baseline is a code-compliant boiler (AFUE = 80%).

### 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%).

### Hours

Not applicable.

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

### Measure Life

The remaining life of an existing unit is 14 years.[396] The measure life of new equipment is 20 years.[397]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Early Replacement Boiler | Residential Heating and Water Heating | 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.

[396] Massachusetts Common Assumption: The remaining life of 14 years was determined by subtracting the average age of existing equipment (estimated by program vendor at 26 years) form the full lifetime of standard efficiency boilers (estimated by program vendor at 40 years).
[397] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*. Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?c=boilers.pr_proc_boilers.

# HVAC – Programmable Thermostats

### Measure Overview

**Description:** Installation of ENERGY STAR® labeled or 7-day programmable thermostats, which give the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.
**Primary Energy Impact:** Natural Gas
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**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 Programmable T-stats installed
ΔMMBtu = Annual MMBtu savings per programmable thermostat installed: 7.7 MMBtu[398]

### 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 that has an ENERGY STAR® or 7-day programmable thermostat installed.

### Hours

Not applicable.

### Measure Life

The measure life is 15 years.[399]

[398] RLW Analytics (2007). *Validating the Impacts of Programmable Thermostats*. Prepared for GasNetworks; Page 2, conversion factor CCF to Therms is 1.024.
[399] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*. Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorProgrammableThermostat.xls.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Programmable Thermostats | Residential Heating and Water Heating | 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 – Furnace (Forced Hot Air) with ECM

### 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
**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 = Installation of furnace with ECM
ΔMMBtu = Annual MMBtu savings for a furnace with ECM. See Table for values.

| Measure | ΔMMBtu |
|---|---|
| Furnace (AFUE = 92%) | 11.8 [400] |
| Furnace w/ECM (AFUE = 92%) | 19.6 [401] |
| Furnace w/ECM (AFUE = 94%) | 23.6 [402] |

### Baseline Efficiency

The baseline efficiency case is a 78% AFUE furnace.

### High Efficiency

The high efficiency case is a new furnace with AFUE >= 92%.

### Hours

Not applicable.

### Measure Life

The measure life is 18 years.[403]

[400] Nexus Market Research (2010). *HEHE Process and Impact Evaluation*. Prepared for GasNetworks.
[401] Ibid.
[402] Ibid.

### 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 478 kWh.[404]

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Furnace (AFUE = 92%) | Residential Heating and Water Heating | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | n/a | n/a |
| Furnace w/ECM (AFUE = 92%) | Residential Heating and Water Heating | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | n/a | n/a |
| Furnace w/ECM (AFUE = 94%) | Residential Heating and Water Heating | 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.

[403] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Furnace*. Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls.
[404] The heating penalty of 21.1 – 19.6 MMBTU is equivalent to 478 kWh for the 92% efficient furnace (1,500,000BTU/ (0.92*3413 BTU/kWh).

# HVAC – Heat Recovery Ventilator

### 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
**Secondary Energy Impact**: None
**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:
ΔMMBtu = Annual MMBtu savings per heat recovery ventilation installed: 7.7 MMBtu[405]
Units = Number of heat recovery ventilation systems installed

### 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.[406]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

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

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Heat Recovery Ventilator | Residential Heating and Water Heating | 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 – Stand Alone Storage Water Heater

### Measure Overview

**Description**: High efficiency water heaters that are not combined with space heating devices.
**Primary Energy Impact**: Natural Gas
**Secondary Energy Impact**: None
**Non-Energy Impact**: None
**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:
Units = Number of stand alone storage water heaters installed
ΔMMBtu = Annual MMBtu savings per stand alone storage water heater EF >= 0.62: 1.9[407]

### Baseline Efficiency

The baseline efficiency case is a stand alone tank water heater with an energy factor of 0.575.

### High Efficiency

The high efficiency case is a stand alone tank water heater with an energy factor of 0.62 or higher.

### Hours

Not applicable.

### Measure Life

The measure life is 13 years.[408]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

[407] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[408] Ibid.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Stand Alone Storage Water Heater (EF >= 0.62) | Residential Heating and Water Heating | 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 – Gas Heating System Replacement (Low Income)

### 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:** Gas
**Secondary Energy Impact:** Electric
**Non-Energy Impact:** Annual Discounted Rate Cost Reduction, One-Time Arrearage Reduction, Annual Fire, Illness and Moving Avoidance Benefits, One-Time Property Value Benefit
**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 = Average annual MMBtu savings per unit: 12.2 MMBtu[409]

### 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 20 years.[410]

### Secondary Energy Impacts

Unit electric savings are deemed based on study results.

[409] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Page 5, Table 1.
[410] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers.* Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?c=boilers.pr_proc_boilers.

| PA | ΔkWh/Unit | ΔkW/Unit |
|---|---|---|
| National Grid | 194[411] | 0.024[412] |

### Non-Energy Impacts

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction (Gas) [413] | $(R3-R4)/Therm | Low Income |
| Annual Non-Resource | Annual Fire, Illness and Moving Avoidance Benefit[414] | $203/Participant | Low Income |
| One-Time Non-Resource | One-Time Arrearage Benefit[415] | $32/Participant | Low Income |
| One-Time Non-Resource | One-Time Property Value Benefit (Electric)[416] | $20.70 x ($Cost/kWh) x kWh saved | Low Income |
| One-Time Non-Resource | One-Time Property Value Benefit (Natural Gas)[417] | $20.70 x ($Cost/therm) x therms saved | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Gas Heating System Replacement | Low-Income Single Family Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.03 | 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**
CFs are developed based on Quantec demand allocation methodology [418]

[411] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Page 5, Table 1.
[412] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[413] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[414] Ibid.
[415] Brown, Marilyn A., Linda Berry, Richard Balzer, and Ellen Faby (1993). *National Impacts of the Weatherization Assistance Program in Single-Family and Small Multifamily Dwellings.* OFWL-CON-326, Oak Ridge National Laboratory, Oak Ridge, Tennessee,
[416] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[417] Ibid.
[418] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.

# HVAC – Gas Weatherization (Low Income)

### 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:** Gas
**Secondary Energy Impact:** Electric
**Non-Energy Impact:** Annual Discounted Rate Cost Reduction, One-Time Arrearage Reduction, Annual Fire, Illness and Moving Avoidance Benefits, One-Time Property Value Benefit
**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 per unit: 13.7 MMBtu[419]

### 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.[420]

[419] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Page 5, Table 1.
[420] 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 Impact

Unit savings are deemed based on study results.

| PA | ΔkWh/Unit | ΔkW/Unit |
|---|---|---|
| National Grid | 70[421] | 0.009[422] |

### Non-Energy Benefits

| Benefit Type | Description | Savings | Notes |
|---|---|---|---|
| Annual Non-Resource | Annual Discounted Rate Cost Reduction (Gas) [423] | $(R3-R4)/Therm | Low Income |
| Annual Non-Resource | Annual Fire, Illness and Moving Avoidance Benefit[424] | $203/Participant | Low Income |
| One-Time Non-Resource | One-Time Arrearage Benefit[425] | $32/Participant | Low Income |
| One-Time Non-Resource | One-Time Property Value Benefit (Electric)[426] | $20.70 x ($Cost/kWh) x kWh saved | Low Income |
| One-Time Non-Resource | One-Time Property Value Benefit (Natural Gas)[427] | $20.70 x ($Cost/therm) x therms saved | Low Income |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Gas Weatherization | Low-Income Single Family Retrofit | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.003 | 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**
CFs are developed based on Quantec demand allocation methodology. [428]

[421] Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid; Page 5, Table 1.
[422] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.
[423] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[424] Ibid.
[425] Brown, Marilyn A., Linda Berry, Richard Balzer, and Ellen Faby (1993). *National Impacts of the Weatherization Assistance Program in Single-Family and Small Multifamily Dwellings.* OFWL-CON-326, Oak Ridge National Laboratory, Oak Ridge, Tennessee,
[426] Oppenheim, Jerry (2000). *Memo - Low Income DSM Program non-energy benefits.*
[427] Ibid.
[428] Estimated using demand allocation methodology described in: Quantec, LLC (2000). *Impact Evaluation: Single-Family EnergyWise Program.* Prepared for National Grid.

# HVAC – Gas Insulation

### Measure Overview

**Description:** Shell insulation upgrades are applied in existing homes including improved insulation in attics, basements and sidewalls.
**Primary Energy Impact:** Natural Gas
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**Sector:** Residential
**Market:** Retrofit
**End Use:** HVAC
**Program:** Residential Gas Weatherization Program

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMbtu = \Delta MMbtu$$

Where:
ΔMMBtu = Annual MMBtu savings for insulation in a gas heated home: 12.3 MMBtu[429]

### 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.

### Measure Life

The measure life is 20 years.[430]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[429] Residential Gas Weatherization Program Impact Evaluation: 2008 Program Year by Summit Blue Consulting July 2009
[430] 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.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Insulation | Gas Weatherization | 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 factors.

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

**Coincidence Factors**
There are no electric savings for this measure.

# HVAC – Gas Air Sealing

### Measure Overview

**Description:** Thermal shell air leaks are sealed through strategic use and location of air-tight materials.
**Primary Energy Impact:** Natural Gas
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**Sector:** Residential
**Market:** Retrofit
**End Use:** HVAC
**Program:** Residential Gas Weatherization Program

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed:

$$\Delta MMbtu = \Delta MMbtu$$

Where:
ΔMMBtu = Annual MMBtu savings for air sealing in a gas heated home: 6.5 MMBtu[431]

### Baseline Efficiency

The baseline efficiency case is the existing building before the air sealing measure is implemented.

### High Efficiency

The baseline efficiency case is the existing building after the air sealing measure is implemented.

### Hours

Not applicable.

### Measure Life

The measure life is 20 years.[432]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[431] Estimated based on previous years' savings per home reported by CSG for the RCS program.
[432] 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.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Air Sealing | Gas Weatherization | 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 factors.

**Realization Rates**
Realization rates are set to 100%.

**Coincidence Factors**
There are no electric savings for this measure.

# HVAC/Hot Water – Integrated Water Heater/Condensing Boiler

### 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**: 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 integrated water heater/condensing boiler
ΔMMBtu = Annual MMBtu savings per integrated water heater/condensing boiler installed: 21.1 MMBtu[433]

### Baseline Efficiency

The baseline efficiency case is an 80% AFUE boiler with a 0.594 EF water heater.

### High Efficiency

The high efficiency case is an integrated water heater/condensing boiler with a 90% AFUE boiler and a 0.9 EF water heater.

### Hours

Not applicable.

### Measure Life

The measure life is 20 years.[434]

[433] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[434] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*. Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?c=boilers.pr_proc_boilers; measure life assumed to be the same as a boiler.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Integrated water heater/condensing boiler | Residential Heating and Water Heating | 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/Hot Water – Integrated Water Heater/Non-Condensing Boiler

### 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**: 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 per integrated water heater/condensing boilers installed
ΔMMBtu = Annual MMBtu savings per integrated water heater/condensing boiler installed: 13.5 MMBtu[435]

### Baseline Efficiency

The baseline efficiency case is an 80% AFUE boiler with a 0.594 EF water heater.

### High Efficiency

The high efficiency case is an integrated water heater/condensing boiler with an 85% AFUE boiler and a 0.86 EF water heater.

### Hours

Not applicable.

### Measure Life

The measure life is 20 years.[436]

[435] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[436] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Qualified Boilers*. Interactive Excel Spreadsheet found at http://www.energystar.gov/index.cfm?c=boilers.pr_proc_boilers; measure life assumed to be the same as a boiler.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Integrated water heater/non-condensing boiler | Residential Heating and Water Heating | 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.

# Hot Water – Condensing Water Heater

### Measure Overview

**Description**: Condensing water heaters recover energy by using either a larger heat exchanger or a second heat exchanger to reduce the flue-gas temperature to the point that water vapor condenses, thus releasing even more energy.
**Primary Energy Impact**: Natural Gas
**Secondary Energy Impact**: None
**Non-Energy Impact**: None
**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 condensing stand alone water heater installed: 7.4 MMBtu[437] |
| Units | = | Number of Condensing Water Heaters installed |

### Baseline Efficiency

The baseline efficiency case is a stand alone tank water heater with an energy factor of 0.575.

### High Efficiency

The high efficiency case is a condensing water heater with an energy factor of 0.8.

### Hours

Not applicable.

### Measure Life

The measure life is 15 years.[438]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[437] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.
[438] Ibid.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Condensing water heaters | Residential Heating and Water Heating | 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.

# Hot Water – Indirect Water Heater

### Measure Overview

**Description**: The installation of a high-efficiency indirect 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.
**Primary Energy Impact**: Natural Gas
**Secondary Energy Impact**: None
**Non-Energy Impact**: None
**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 indirect water heater unit installed: 8.0 MMBtu[439]
Units = Number of savings indirect water heaters installed

### Baseline Efficiency

The baseline efficiency case is a stand alone tank water heater with an energy factor of 0.575.

### High Efficiency

The high efficiency case is an indirect water heater attached to an ENERGY STAR® rated forced hot water gas boiler.

### Hours

Not applicable.

### Measure Life

The measure life is 20 years.[440]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[439] Nexus Market Research (2010). *HEHE Process and Impact Evaluation.* Prepared for GasNetworks.
[440] GDS Associates, Inc. (2003). *Consumer Guide to Home Energy Savings.* Prepared for the 8th ed. ACEEE; Table 6.6.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Indirect Water Heaters | Residential Heating and Water Heating | 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.

# Hot Water – Tankless Water Heaters

### Measure Overview

**Description**: The installation of a high-efficiency tankless water heater with electronic ignition and an Energy Factor (EF) of at least 0.82. 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**: 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 tankless water heater (EF >= 0.82) installed: 9.7 MMBtu[441]
Units = Number of tankless water heaters installed.

### Baseline Efficiency

The baseline efficiency case is a stand alone tank water heater with an energy factor of 0.575.

### High Efficiency

The high efficiency case is a tankless water heater with an energy factor of 0.82 or greater.

### Hours

Not applicable.

### Measure Life

The measure life is 20 years.[442]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[441] Nexus Market Research (2010). *HEHE Process and Impact Evaluation*. Prepared for GasNetworks.
[442] DOE (2008). *ENERGY STAR® Residential Water Heaters: Final Criteria Analysis*. Prepared for the DOE; Page 10.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Tankless Water Heaters (EF>=0.82) | Residential Heating and Water Heating | 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.

# Behavior – OPOWER Gas

### Measure Overview

**Description:** The OPOWER programs send energy use reports to participating gas customers in order to change customers' energy-use behavior. In 2010, the program was planned with only one measure for all cohorts. In 2011, the program was planned with unique measures for each cohort. In 2011, the program's name was changed to Behavior/Feedback.
**Primary Energy Impact:** Natural Gas
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**Sector:** Residential
**Market:** Products and Services
**End Use:** Behavior
**Program:** OPOWER 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: 1.006 MMBtu[443]
$MMbtu_{BASE}$ = Average baseline consumption MMBtu per unit: 130.7 MMBtu[444]
%SAVE = Annual percent of MMBtu savings per unit: 0.77%[445]

**OPOWER Program - Gas Savings Factors**

| Measure Name | $MMBtu_{BASE}$ | %SAVE | ΔMMBtu |
|---|---|---|---|
| CUSTSERV | 130.7 | 0.77% | 1.006 |

### Baseline Efficiency

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

### High Efficiency

The high efficiency case is a customer who does receive OPOWER program reports.

### Hours

Not applicable.

[443]ODC and Navigant (2011). *MA Cross-Cutting Behavioral Program Evaluation.* Prepared for MA Energy Efficiency Advisory Council. Study 17 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.
[444]Ibid.
[445]Ibid.

### 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.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| CUSTSERV | OPOWER | 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**
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.

# Commercial and Industrial Natural Gas Efficiency Measures

# HVAC – Programmable Thermostat

### Measure Overview

**Description:** Installation of ENERGY STAR® labeled or 7-day programmable thermostats 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:** None
**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: 7.5 MMBtu[446]

### 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 an ENERGY STAR® labeled or 7-day programmable thermostat installed.

### Hours

Not applicable.

### Measure Life

The measure life is 15 years.[447]

[446] RLW Analytics (2007). *Validating the Impacts of Programmable Thermostats*; Page 2, conversion factor CCF to Therms is 1.024.
[447] Environmental Protection Agency (2010). *Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat*. Interactive Excel Spreadsheet found at www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorProgrammableThermostat.xls.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Programmable Thermostat | C&I Retrofit | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Programmable Thermostat | C&I Direct Install | 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 (Retrofit only)

### 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:** None
**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 boiler reset control
ΔMMBtu = Average annual MMBtu savings per unit: 35.5 MMBtu[448]

### 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 20 years.[449]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[448] 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.
[449] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; the study references "KEMA (2003). *CA Statewide Commercial Sector NG EE Potential Study, Study ID #SW061*. Prepared for PG&E; Appendix D."

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Boiler Reset Controls | C&I Retrofit | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Boiler Reset Controls | C&I Direct Install | 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 – Condensing Unit Heater

### Measure Overview

**Description:** Installation of a Condensing Gas Fired Unit Heater for space heating with capacity of 151 – 400 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[450]

### 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.[451]

### High Efficiency

The high efficiency case is a condensing gas unit heater with 90% AFUE or greater.

### Hours

Not applicable.

### Measure Life

The measure life is 18 years.[452]

[450] 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.
[451] ASHRAE Standard 90.1-2007; Table 6.8.1E.
[452] Ecotrope (2003). *Natural Gas Efficiency and Conservation Measure Resource Assessment*. Prepared for the Energy Trust of Oregon.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Condensing Unit Heater | C&I NC | 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 – Gas-Fired Low Intensity Infrared Heating

### 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: 74.4 MMBtu[453]

### 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.

### Measure Life

The measure life is 17 years.[454]

[453] The savings are based on modeled data form 62 low-intensity infrared heaters installed through the Columbia Gas of MA custom commercial and industrial energy efficiency program. See "Infrared Samples - Bay State Gas.xls" for additional project data.
[454] GDS Associates, Inc. (2004). *The Maximum Achievable Cost-Effective Potential Gas DSM*. Prepared for Questar Gas.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Low-Intensity Infrared Heating Unit | C&I NC | 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 – High Efficiency Natural Gas Boiler

### Measure Overview

**Description:** The installation of a high efficiency natural gas fired steam boiler or hot water boiler. High-efficiency boilers can take advantage of improved design, sealed combustion and condensing flue gases in a second heat exchanger to achieve improved efficiency. This measure incorporates steam boilers, condensing boilers and hydronic boilers of all capacities.
**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

### Notes

This measure uses deemed savings values, but is a strong candidate for developing a deemed calculation with inputs provided by the customer. In particular, the C&I evaluation project planned to start in 2010 should provide useful results to inform a deemed calculation and factor values.

### 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 10 for values.

**Table 10: MMBtu Savings by Boiler Type[455]**

| Boiler Type/Size | ΔMMBTU/Unit |
|---|---|
| Steam Boiler 82% AFUE or greater | 36.5 |
| Condensing Boiler <=300 MBH - 90% AFUE or greater | 22.1 |
| Condensing Boiler 301-499 MBH - 90% thermal efficiency or greater | 42.3 |
| Condensing Boiler 500-999 MBH - 90% thermal efficiency or greater | 77.1 |
| Condensing Boiler 1000-1700 MBH - 90% thermal efficiency or greater | 142.6 |
| Condensing Boiler 1701+ MBH - 90% thermal efficiency or greater | 249 |
| Hydronic Boiler <= 300 MBH – 85% AFUE or greater | 16.8 |
| Hydronic Boiler 301-499 MBH – 85% thermal efficiency or greater | 35.3 |
| Hydronic Boiler 500-999 MBH – 85% thermal efficiency or greater | 66.2 |
| Hydronic Boiler 1000-1700 MBH – 85% thermal efficiency or greater | 119.1 |
| Hydronic Boiler 1701+ MBH – 85% thermal efficiency or greater | 150.0 |

[455] For Steam Boiler and Hydronic Boilers: Opinion Dynamics Corporation (2007). *Evaluation Study of KeySpan's Commercial and Industrial High Efficiency Heating Equipment Program, Final.* Prepared for KeySpan Energy Delivery; Page 40. For Condensing Boilers: KEMA (2011). *Prescriptive Condensing Boiler Impact Evaluation, Project 5 Prescriptive Gas.* Study 35 2010 Massachusetts Electric Energy Efficiency Annual Report.
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### 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 with the 2007 Supplement or ASHRAE 90.1-2007. The requirements for gas-fired boilers differ slightly between the two, so the less stringent requirements as presented in IECC 2006 are referenced below. Table 11 details the specific efficiency requirements by equipment type and capacity.

**Table 11: Boilers, Gas-Fired, Minimum Efficiency Requirements[456]**

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency[a] |
|---|---|---|---|
| Boiler, Gas-Fired | <300,000 Btu/h | Hot Water | 80% AFUE |
| | | Steam | 75% AFUE |
| | >=300,000 Btu/h and <=2,500,000 Btu/h | Minimum Capacity[a] | 75% $E_t$ and 80% $E_c$ |
| | >2,500,000 Btu/h | Hot Water | 80% $E_c$ |
| | | Steam | 80% $E_c$ |

a. Minimum ratings as provided for and allowed by the unit's controls

### 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.[457]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

[456] Adapted form 2007 Supplement to the 2006 International Energy Conservation Code; Page 15, Table 503.2.3(5).
[457] ASHRAE Applications Handbook (2003); Page 36.3.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Condensing Boiler | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Hydronic Boiler | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Steam Boiler | C&I NC | 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 – High Efficiency Natural Gas Warm Air Furnace

### Measure Overview

**Description:** The installation of a high efficiency natural gas warm air furnace with or without 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

### Notes

This measure has significant savings and is thus a good candidate for a deemed calculation rather than a deemed savings value.

### Algorithms for Calculating Primary Energy Impact

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:
Unit = Installed high efficiency warm air furnace
ΔMMBtu = Average annual MMBtu savings per unit. See Table 12 for values.

**Table 12: MMBtu Savings by Furnace Type**[458]

| Boiler Type/Size | ΔMMBTU |
|---|---|
| Furnace AFUE => 92% | 21.1 |
| Furnace AFUE => 92% w/ ECM | 19.6[459] |
| Furnace AFUE => 94% w/ ECM | 23.6 |

### 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) 2006 with the 2007 Supplement or

[458] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks.
[459] NYSERDA Deemed Savings Database.

ASHRAE 90.1-2007. The two documents present nearly identical requirements for gas-fired furnaces, so only the requirements as presented in IECC 2006 are referenced below. Table 13 details the specific efficiency requirements by equipment type and capacity.

**Table 13: Warm Air Furnaces and Combination Warm Air Furnace/Air-Conditioning Units, Warm Air Duct Furnaces, Minimum Efficiency Requirements**[460]

| Equipment Type | Size Category (Input) | Subcategory or Rating Condition | Minimum Efficiency |
|---|---|---|---|
| Warm air furnaces, gas fired | < 225,000 Btu/h | - | 78% AFUE or 80% Et[b] |
| | >= 225,000 Btu/h | Maximum capacity[a] | 80% $E_t$[c] |
| Warm air duct furnaces, gas fired | All capacities | Maximum capacity[a] | 80% $E_c$ |

a. Minimum and maximum ratings as provided for and allowed by the unit's controls.
b. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.
c. Units must also include an Intermittent Ignition Device (IID), have jackets not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

### High Efficiency

The high efficiency scenario assumes a gas-fired furnace 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 18 years.[461]

### 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 478 kWh[462].

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| HE Natural Gas Furnace | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| HE Natural Gas Furnace w/ ECM | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |

[460] Adapted form 2006 International Energy Conservation Code; Page 36, Table 503.2.3(4).
[461] ASHRAE Applications Handbook (2003); Page 36.3.
[462] The heating penalty of 21.1 – 19.6 MMBTU is equivalent to 478 kWh for the 92% efficient furnace (1,500,000BTU/ (0.92*3413 BTU/kWh).

**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/Hot Water – Combined High Efficiency Boiler and Water Heater

### 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 14 for values.

**Table 14: MMBtu Savings by Boiler/Water Heater Combo Type[463]**

| Boiler/Water Heater Combo Type | ΔMMBTU |
|---|---|
| Integrated water heater/condensing boiler (0.86 EF, 0.85 AFUE) | 20.0 |
| Integrated water heater/condensing boiler (0.86 EF, 0.90 AFUE) | 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% or >=85%.

### Hours

Not applicable.

[463] Based on an analysis conducted by Summit Blue, Inc. See "SB Gas Networks Calculations for Combined HVAC and DHW.xlsx" for source calculations.

### Measure Life

The measure life is 25 years.[464]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Integrated Water Heater/Condensing Boiler | C&I NC | 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.

[464] ASHRAE Applications Handbook (2003); Page 36.3, assumes combined boiler and water heating systems have a measure life similar to a typical boiler.

# Hot Water – Condensing Stand-Alone Water Heater

### Measure Overview

**Description:** Installation of a condensing stand alone water heater with a capacity between 75-300 MBH and thermal efficiency of 95% or greater.
**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:

| | | |
|---|---|---|
| Unit | = | Installed condensing stand-alone water heater |
| ΔMMBtu | = | Average annual MMBtu savings per unit (75,000 – 300,000 BTU) installed: 25.0 MMBtu[465] |

### Baseline Efficiency

The baseline efficiency case is a stand alone tank water heater with a thermal efficiency of 80%.[466]

### High Efficiency

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.

### Hours

Not applicable.

### Measure Life

The measure life is 15 years.[467]

[465] 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."
[466] ASHRAE Standard 90.1-2007; Table 7.8
[467] 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."

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Condensing Stand-Alone Water Heater | C&I NC | 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.

# Hot Water – Pre-Rinse Spray Valve

### 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: 33.6 MMBtu[468]

### 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.[469]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[468] SBW Consulting (2004). *EM&V Report for the CUWCC Pre-Rinse Spray Head Distribution Program.* Prepared for the California Urban Water Conservation Council; Page 20, savings of 0.92 therms per day * 365 days per year = 335.8 therms.
[469] Veritec Consulting (2005). *Region of Waterloo Pre-Rinse Spray Valve Pilot Study, Final Report*; Page 8.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| C&I Water | C&I water savings [470] | 62,305 Gallons/Unit |
| C&I Sewer | C&I sewer water savings [471] | 62,305 Gallons/Unit |

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Pre-Rinse Spray Valve | C&I Retrofit | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| Pre-Rinse Spray Valve | C&I Direct Install | 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.

[470] SBW Consulting (2004). *EM&V Report for the CUWCC Pre-Rinse Spray Head Distribution Program.* Prepared for the California Urban Water Conservation Council; Page 18, savings based on assumptions of 2.24 gallons per minute flow rate, 1.27 hours per day, 365 days per year.
[471] Ibid.

# Hot Water – Repair/Replace Malfunctioning Steam Trap

### Measure Overview

**Description:** Repair or replace malfunctioning steam traps.
**Primary Energy Impact:** Natural Gas
**Secondary Energy Impact:** None
**Non-Energy Impact:** None
**Sector:** Commercial & Industrial
**Market:** Retrofit
**End Use:** HVAC, Process
**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: 25.3 MMBtu[472]

### 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.

### Measure Life

The measure life is 1 year.[473]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

[472] Assumption based on historical steam trap surveys.
[473] Massachusetts Common Assumption.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Steam Traps | 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.

# Hot Water – Low Flow Shower Heads

### 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

### 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[474]

### 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.

### Measure Life

The measure life is 10 years.[475]

[474]US DOE: Federal Energy Management Program (2010). *Cost Calculator for Faucets & Shower Heads*. http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html#output. Accessed on 4/6/2010 using baseline 2.5 gpm and retrofit model at 1.5 gpm. Also supported by: GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; measure C-WH-15.
[475] US DOE: Federal Energy Management Program (2010). *Cost Calculator for Faucets & Shower Heads*. http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html#output. Accessed on 4/6/2010; Optimal Energy, ACEEE, VEIC, Resource Insight and Energy & Environmental Analysis (2006). Natural Gas Energy Efficiency Resource Development Potential in New York- Final Report. Prepared for NYSERDA; Page 27, Appendix B.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Low Flow Shower Heads | C&I Direct Install | 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.

# Hot Water – Faucet Aerator

### 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

### 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[476]

### 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.

### Measure Life

The measure life is 10 years.[477]

[476] US DOE: Federal Energy Management Program (2010). *Cost Calculator for Faucets & Shower Heads.* http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html#output. Accessed on 4/6/2010 using baseline 2.2 gpm and retrofit model at 1.5 gpm. Same results also form: GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; measure C-WH-15.
[477] US DOE: Federal Energy Management Program (2010). *Cost Calculator for Faucets & Shower Heads.* http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html#output. Accessed on 4/6/2010; Optimal Energy, ACEEE, VEIC, Resource Insight and Energy & Environmental Analysis (2006). Natural Gas Energy Efficiency Resource Development Potential in New York- Final Report. Prepared for NYSERDA; Page 27, Appendix B.

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings |
|---|---|---|
| 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Faucet Aerator | C&I Direct Install | 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.

# Hot Water – High Efficiency Indirect Water Heater

## Measure Overview

**Description:** The installation of a high-efficiency indirect 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.
**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:
Unit = Installed high efficiency indirect water heater
ΔMMBtu = Average annual MMBtu savings per unit: 30.4 MMBtu[478]

## Baseline Efficiency

The baseline efficiency case is a code compliant gas-fired storage water heater with an assumed energy factor of 0.59. The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in Chapter 13 of the State Building Code, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2009 with the 2007 Supplement or ASHRAE 90.1-2007. The two documents present nearly identical requirements for gas-fired storage water heaters. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace.

## High Efficiency

The high efficiency scenario is an indirect water heater with a Combined Appliance Efficiency (CAE) of 85% or greater.

## Hours

Not applicable.

[478] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Appendix B-2.

### Measure Life

The measure life is 15 years.[479]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| HE Indirect Water Heater | C&I NC | 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.

[479] Ibid.

# Hot Water – High Efficiency Tankless Water Heater

### Measure Overview

**Description**: The installation of a high-efficiency tankless water heater with electronic ignition and an Energy Factor of at least 0.82. 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:
Unit = Installed high efficiency tankless water heater
ΔMMBtu = Average annual MMBtu savings per unit: 7.1 MMBtu[480]

### Baseline Efficiency

The baseline efficiency case is a code compliant gas-fired storage water heater with an assumed Energy Factor of 0.59. The baseline efficiency 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) 2006 with the 2007 Supplement or ASHRAE 90.1-2007. The two documents present nearly identical requirements for gas-fired storage water heaters. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace.

### High Efficiency

The high efficiency equipment is a gas-fired instantaneous hot water heater with an Energy Factor of at least 0.82.

### Hours

Not applicable.

[480] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Appendix B-2.

### Measure Life

The measure life is 20 years.[481]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Tankless Water Heater | C&I NC | 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.

[481] Hewitt, D. Pratt, J. & Smith, G. (2005) *Tankless Gas Water Heaters: Oregon Market Status*. Prepared for the Energy Trust of Oregon.

# Hot Water – High Efficiency Free Standing Water Heater

### Measure Overview

**Description:** The installation of a high efficiency ENERGY STAR® freestanding water heater with an Energy Factor of at least 0.62, a nominal input of 75,000 BTU/hour, or less and a rated storage volume from 20 to 100 gallons.
**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:
Unit = Installed high efficiency free-standing water heater
ΔMMBtu = Average annual MMBtu savings per unit: 0.76 MMBtu[482]

### Baseline Efficiency

The baseline efficiency case is a code compliant gas-fired free standing water heater with an assumed Energy Factor of 0.594. The baseline efficiency 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) 2006 with the 2007 Supplement or ASHRAE 90.1-2007. The two documents present nearly identical requirements for gas-fired storage water heaters. The assumed efficiency slightly exceeds the minimum required by code to reflect the typical baseline unit available in the marketplace.

### High Efficiency

The high efficiency case is an ENERGY STAR® gas-fired freestanding hot water heater with an Energy Factor of at least 0.62 and a nominal input of 75,000 BTU/hour.

### Hours

Not applicable.

[482] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Appendix A-2.

### Measure Life

The measure life is 10 years.[483]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| HE Free Standing Water Heater | C&I NC | 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.

[483] GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts.* Prepared for GasNetworks; Appendix A-2.

# Food Service – Commercial Gas-Fired Oven

### Measure Overview

**Description:** Installation of High Efficiency Gas Ovens
**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 oven
ΔMMBtu = Average annual MMBtu savings per unit. See Table 15 for values.

**Table 15: Baseline and High Efficiency Ratings and MMBtu Savings by Oven Type**

| Oven Type | Baseline Efficiency | High Efficiency | ΔMMBTU[484] |
|---|---|---|---|
| High Efficiency Gas Convection Oven | 30% | >= 40% | 24.8[485] |
| High Efficiency Gas Combination Oven | 35% Heavy Load | >= 40% | 40.3 |
| High Efficiency Gas Conveyer Oven | 20% Heavy Load | >= 40% | 84.5 |
| High Efficiency Gas Rack Oven | 30% | >= 50% | 211.3 |

### Baseline Efficiency

The baseline efficiency case is a standard efficiency oven. See Table 15 for values by oven type.

### High Efficiency

High efficiency case is an oven that meets or exceeds the high efficiency ratings per oven type shown in Table 15.

### Hours

Not applicable.

### Measure Life

The measure life is 12 years for both convection and combination ovens. [486]

[484] 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.
[485] CEE (2008). *Technology Opportunity Assessment: Convection Ovens*; Page 5.

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| HE Gas Convection Oven (>=40%) | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| HE Gas Combination Oven (>=40%) | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| HE Gas Conveyer Oven (>=40%) | C&I NC | 1.00 | 1.00 | 1.00 | n/a | n/a | n/a | n/a |
| HE Gas Rack Oven (>=50%) | C&I NC | 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.

[486] 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.

# Food Service – Commercial Gas-Fired Griddle

### 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[487]

### 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.[488]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

[487] 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.
[488] Ibid.

### Non-Energy Impacts

There are no non-energy impacts for this measure.

### Impact Factors for Calculating Adjusted Gross Savings

| Measure Name | Program | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Gas-Fired Griddle | C&I NC | 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

### 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[489] |
| $A_{BASE}$ | = | Baseline equipment daily cooking energy (Btu/day). Default = 85,500 Btu. |
| $\eta_{BASE}$ | = | 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. |
| $\eta_{EE}$ | = | Efficient equipment heavy-load cooking efficiency. |
| $B_{EE}$ | = | Efficiency equipment daily fryer idle time (hours). Default 13.44 hrs. |
| $IDLE_{EE}$ | = | Efficient equipment idle energy rate (Btu/h). |
| $C_{EE}$ | = | Efficient equipment daily total preheat energy (Btu). Default = 15,500 Btu. |
| 365 | = | Days per year. |
| 1,000,000 | = | Btu per MMBtu. |

### 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.[490]

[489] Environmental Protection Agency (2009). *Life Cycle Cost Estimate for ENERGY STAR Gas Fryer.* Interactive Excel Spreadsheet found at http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Commercial_Gas_Fryers.xls.
[490] 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.

### 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.[491]

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Commercial Fryer | C&I NC | 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.

[491] Ibid.

# Food Service – Commercial Gas-Fired Steamer

### 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
**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:

$$\Delta MMBtu = (PANS)(SAVE)$$

Where:

| | | |
|---|---|---|
| Unit | = | Installed high efficiency gas-fired steamer |
| ΔMMBtu | = | Average annual MMBTU savings for default condition of three pans: 153.6 MMBtu |
| PANS | = | Efficient equipment number of pans. Default is 3 pans. |
| SAVE | = | Average savings per pan: default of 51.2 MMBtu[492] |

### Baseline Efficiency

The baseline efficiency case is a typical boiler-based steamer with the following operating parameters: Preheat Energy = 18,000 Btu, Idle Energy Rate = 3,667 Btu/h/pan, Heavy Load Efficiency = 15.0%, Production Capacity = 21.7 lbs/h/pan, Average Water Consumption Rate = 40 gal/h, and Percentage of Time in Constant Steam Mode = 90%.[493]

### High Efficiency

The high efficiency case is an ENERGY STAR® qualified gas-fired steamer with the following operating parameters: Preheat Energy = 7,000 Btu, Idle Energy Rate = 2,083 Btu/h/pan, Heavy Load Efficiency =

[492] Food Service Technology Center (2010). *Gas Steamer Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gsteamercalc.php. Accessed on 10/20/2010; the estimated annual MMBtu savings per pan is derived using the referenced cost calculator and the operating parameters described in the Baseline Efficiency, High Efficiency, and Hours sections. The savings per pan is found by averaging the per pan savings estimates for 3-, 4-, 5-, and 6-pan steamers.
[493] Food Service Technology Center (2010). *Gas Steamer Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gsteamercalc.php. Accessed on 10/20/2010.

38.0%, Production Capacity = 18.3 lbs/h/pan, Average Water Consumption Rate = 3.0 gal/h, and Percentage of Time in Constant Steam Mode = 0%.[494]

### Hours

The deemed savings assumes 4,380 annual operating hours (12 hours a day * 365 days/year). [495]

### Measure Life

The measure life is 10 years.[496]

### Secondary Energy Impacts

There are no secondary energy impacts for this measure.

### Non-Energy Impacts

| Benefit Type | Description | Savings[497] |
|---|---|---|
| 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Gas-Fired Steamer | C&I NC | 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.

[494] Ibid.
[495] Consortium for Energy Efficiency (2010). *Program Design Guidance: Steamers*.
[496] Ibid.
[497] Food Service Technology Center (2010). *Gas Steamer Life-Cycle Cost Calculator*. http://www.fishnick.com/saveenergy/tools/calculators/gsteamercalc.php. Accessed on 10/20/2010; the estimated water savings is derived using the referenced cost calculator and the operating parameters described in the Baseline Efficiency, High Efficiency, and Hours sections. The savings per pan is found by averaging the per pan savings estimates for 3-, 4-, 5-, and 6-pan steamers.

# Custom Measures

### 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 | ISR | SPF | $RR_E$ | $RR_{SP}$ | $RR_{WP}$ | $CF_{SP}$ | $CF_{WP}$ |
|---|---|---|---|---|---|---|---|---|
| Custom | 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.

# Appendices

# Appendix A: Common Lookup Tables

**Table 16: Lighting Power Densities Using the Building Area Method ($WATTS_{b,i}$)[498]**

| Building Area Type | Lighting Power Density ($W/ft^2$) |
|---|---|
| Automotive Facility | 0.9 |
| Convention Center | 1.2 |
| Court House | 1.2 |
| Dining: Bar Lounge/Leisure | 1.3 |
| Dining: Cafeteria/Fast Food | 1.4 |
| Dining: Family | 1.6 |
| Dormitory | 1.0 |
| Exercise Center | 1.0 |
| Gymnasium | 1.1 |
| Healthcare-Clinic | 1.0 |
| Hospital | 1.2 |
| Hotel | 1.0 |
| Library | 1.3 |
| Manufacturing Facility | 1.3 |
| Motel | 1.0 |
| Motion Picture Theatre | 1.2 |
| Multi-Family | 0.7 |
| Museum | 1.1 |
| Office | 1.0 |
| Parking Garage | 0.3 |
| Penitentiary | 1.0 |
| Performing Arts Theatre | 1.6 |
| Police/Fire Station | 1.0 |
| Post Office | 1.1 |
| Religious Building | 1.3 |
| Retail | 1.5 |
| School/University | 1.2 |
| Sports Arena | 1.1 |
| Town Hall | 1.1 |
| Transportation | 1.0 |
| Warehouse | 0.8 |
| Workshop | 1.4 |

**Table 17: Lighting Power Densities Using the Space-by-Space Method ($WATTS_{b,i}$)[499]**

| Common Space Types | Lighting Power Density ($W/ft^2$) |
|---|---|
| Office – Enclosed | 1.1 |
| Office - Open Plan | 1.1 |
| Conference/Meeting/Multipurpose | 1.3 |

[498] IECC 2009 Lighting Provisions, Section 505 Electrical Power and Lighting Systems, Table 505.5.2 Interior Lighting Power Allowances, Lighting provisions pgs.5-6.
[499] 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 ($W/ft^2$) |
|---|---|
| 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 |
| **Building Specific Space Types** | **Lighting Power Density (W/ft2)** |
| Gymnasium/Exercise Center | |
| Exercise Area | 0.9 |
| Playing Area | 1.4 |
| Court House/Police Station/Penitentiary | |
| Courtroom | 1.9 |

| Common Space Types | Lighting Power Density ($W/ft^2$) |
|---|---|
| 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 |
| Fellowship Hall | 0.9 |
| Retail | |
| Sales Area [for accent lighting, see Section 9.6.3(c)] | 1.7 |
| Mall Concourse | 1.7 |
| Sports Arena | |

| Common Space Types | Lighting Power Density ($W/ft^2$) |
|---|---|
| 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 18: EPACT 1992 Baseline Motor Efficiencies[500]**

| 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 |

**Table 19: Minimum Premium Efficiency Motors Compliance Efficiencies[501]**

| 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 |

[500] Energy Policy Act of 1992
[501] NEMA Premium MG1-2006 Table 12-12

| Motor Horsepower | Open Drip Proof | | | Totally Enclosed Fan Cooled | | |
|---|---|---|---|---|---|---|
| | 1200 rpm | 1800 rpm | 3600 rpm | 1200 rpm | 1800 rpm | 3600 rpm |
| 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 |

**Table 20: Non-Energy Impacts for Commercial Lighting Measures [502]**

| End-Use | Measure Type | Impact | | Unit |
|---|---|---|---|---|
| | | Retrofit | Lost Opportunity | |
| Lighting | LED Exit Sign | $33.65 | $33.45 | Exit Sign |
| Lighting | CFL Fixtures | $18.67 | $17.93 | Fixture |
| Lighting | Fluorescent Lighting (T8 Lamp/Ballast) | $0.41 | $0.00 | Fixture |
| Lighting | T8 Lamp/Ballast + Reflectors | $0.91 | $0.00 | Fixture |
| Lighting | Occupancy Sensors | $6.69 | $6.69 | ΔkW |
| Lighting | Daylight Dimming | $0.00 | $0.00 | ΔkW |

[502] Ibid.

# Appendix B: Net to Gross Impact Factors

| Residential Electric Efficiency Measures | | | | | |
|---|---|---|---|---|---|
| **Measure** | **PA** | **FR** | **$SO_P$** | **$SO_{NP}$** | **NTG** |
| **Residential New Construction & Major Renovation** | | | | | |
| LED Fixture | National Grid | 0% | 0% | 0% | 100% |
| **Residential Cooling & Heating Equipment** | | | | | |
| Brushless Furnace Fan Motor | National Grid | 15% | 0% | 0% | 85% |
| CoolSmart AC (SEER >= 15 / EER >= 12.5) | National Grid | 15% | 0% | 0% | 85% |
| CoolSmart AC (SEER >= 15 / EER >= 13) | National Grid | 15% | 0% | 0% | 85% |
| CoolSmart AC (SEER 14.5 / EER 12) | National Grid | 15% | 0% | 0% | 85% |
| CoolSmart AC Digital Check-up/Tune-up | National Grid | 15% | 0% | 0% | 85% |
| **MassSAVE** | | | | | |
| Air Sealing, Electric | National Grid | 7% | 0% | 0% | 93% |
| Air Sealing, Gas | National Grid | 7% | 0% | 0% | 93% |
| Air Sealing, Oil | National Grid | 7% | 0% | 0% | 93% |
| Air Sealing, Other FF | National Grid | 7% | 0% | 0% | 93% |
| Boiler Reset Controls | National Grid | 0% | 0% | 0% | 100% |
| DHW ISMs, Electric | National Grid | 25% | 0% | 0% | 75% |
| DHW ISMs, Gas | National Grid | 25% | 0% | 0% | 75% |
| DHW ISMs, Oil | National Grid | 25% | 0% | 0% | 75% |
| DHW ISMs, Other FF | National Grid | 25% | 0% | 0% | 75% |
| Duct Insulation, Electric | National Grid | 20% | 8% | 50% | 138% |
| Duct Insulation, Gas | National Grid | 20% | 8% | 50% | 138% |
| Duct Insulation, Oil | National Grid | 20% | 8% | 50% | 138% |
| Duct Insulation, Other FF | National Grid | 20% | 8% | 50% | 138% |
| Duct Seal, Electric | National Grid | 7% | 0% | 0% | 93% |
| Duct Seal, Oil | National Grid | 7% | 0% | 0% | 93% |
| Duct Seal, Other FF | National Grid | 7% | 0% | 0% | 93% |
| ES Window, Electric | National Grid | 0% | 0% | 0% | 100% |
| ES Window, Gas | National Grid | 0% | 0% | 0% | 100% |
| ES Window, Oil | National Grid | 0% | 0% | 0% | 100% |
| ES Window, Other FF | National Grid | 0% | 0% | 0% | 100% |
| Heating System Replacement, Gas | National Grid | 28% | 0% | 0% | 72% |
| Heating System Replacement, Oil | National Grid | 28% | 0% | 0% | 72% |
| Heating System Replacement, Other FF | National Grid | 28% | 0% | 0% | 72% |
| Indirect Water Heater, Oil | National Grid | 25% | 0% | 0% | 75% |
| Indirect Water Heater, Other FF | National Grid | 25% | 0% | 0% | 75% |
| Insulation, Electric | National Grid | 20% | 8% | 50% | 138% |
| Insulation, Gas | National Grid | 20% | 8% | 50% | 138% |
| Insulation, Oil | National Grid | 20% | 8% | 50% | 138% |
| Insulation, Other FF | National Grid | 20% | 8% | 50% | 138% |
| Refrigerator (ES Value) | National Grid | 35% | 36% | 0% | 101% |

| | | | | | |
|---|---|---|---|---|---|
| Refrigerator (Retirement Value) | National Grid | 35% | 36% | 0% | 101% |
| Screw-in Bulbs | National Grid | 22% | 19% | 0% | 97% |
| Screw-in Bulbs (piggyback) | National Grid | 22% | 19% | 0% | 97% |
| Thermostats, Electric | National Grid | 11% | 0% | 0% | 89% |
| **Multi-Family Retrofit** | | | | | |
| Air Sealing (FF) | National Grid | 3% | 0% | 0% | 97% |
| CFL (Electric) | National Grid | 3% | 0% | 0% | 97% |
| CFL (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| Common Area Int Fixtures | National Grid | 3% | 0% | 0% | 97% |
| Common Area Occupancy Sensors | National Grid | 3% | 0% | 0% | 97% |
| DHW Measures (FF) | National Grid | 3% | 0% | 0% | 97% |
| DHW Measures (Electric) | National Grid | 3% | 0% | 0% | 97% |
| DHW Showerheads/Aerators (Electric) | National Grid | 3% | 0% | 0% | 97% |
| DHW Showerheads/Aerators (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| DHW Tank/Pipe Wrap (Electric) | National Grid | 3% | 0% | 0% | 97% |
| DHW Tank/Pipe Wrap (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| Fixtures (Electric) | National Grid | 3% | 0% | 0% | 97% |
| Fixtures (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| Heat Pump Tune-Up (Electric) | National Grid | 3% | 0% | 0% | 97% |
| Indoor Fixture | National Grid | 8% | 4% | 0% | 96% |
| Insulation (Electric) | National Grid | 3% | 0% | 0% | 97% |
| Insulation (FF) | National Grid | 3% | 0% | 0% | 97% |
| Outdoor Fixture | National Grid | 12% | 7% | 0% | 95% |
| Programmable Thermostats (Electric) | National Grid | 3% | 0% | 0% | 97% |
| Programmable Thermostats (FF) | National Grid | 3% | 0% | 0% | 97% |
| Refrigerator (ES Value) | National Grid | 3% | 0% | 0% | 97% |
| Refrigerator (Retirement Value) | National Grid | 3% | 0% | 0% | 97% |
| Refrigerators/Freezers (Electric Heat) | National Grid | 3% | 0% | 0% | 97% |
| Refrigerators/Freezers (Non-Electric Heat) | National Grid | 3% | 0% | 0% | 97% |
| Room AC | National Grid | 35% | 0% | 0% | 65% |
| Room AC | National Grid | 35% | 0% | 0% | 65% |
| Screw-in Bulbs | National Grid | 3% | 0% | 0% | 97% |
| Smart Strips | National Grid | 0% | 0% | 0% | 100% |
| SPACE Air Sealing (Electric) | National Grid | 3% | 0% | 0% | 97% |
| SPACE Air Sealing (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| SPACE Insulation (Electric) | National Grid | 3% | 0% | 0% | 97% |
| SPACE Insulation (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| SPACE Thermostats (Electric) | National Grid | 3% | 0% | 0% | 97% |
| SPACE Thermostats (Non-Electric) | National Grid | 3% | 0% | 0% | 97% |
| **OPOWER Program** | | | | | |
| CUSTSERV | National Grid | 0% | 0% | 0% | 100% |
| **ENERGY STAR Lighting** | | | | | |
| Indoor Fixture | National Grid | 8% | 4% | 0% | 96% |
| LED Fixture | National Grid | 0% | 0% | 0% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| LED Lamp | National Grid | 0% | 0% | 0% | 100% |
| Outdoor Fixture | National Grid | 12% | 7% | 0% | 95% |
| Screw-in Bulbs* | National Grid | 57% | 0% | 0% | 43% |
| Screw-in Bulbs (Hard to Reach)* | National Grid | 40% | 0% | 0% | 60% |
| Screw-in Bulbs (School Fundraiser)* | National Grid | 0% | 0% | 0% | 100% |
| Screw-in Bulbs (Specialty bulbs)* | National Grid | 40% | 0% | 0% | 60% |
| Torchiere | National Grid | 6% | 3% | 0% | 97% |
| **ENERGY STAR Appliances** | | | | | |
| Computer Monitors | National Grid | 0% | 0% | 0% | 100% |
| Freezer Rebate | National Grid | 0% | 0% | 0% | 100% |
| LCD/TV | National Grid | 0% | 0% | 0% | 100% |
| PC Computers | National Grid | 0% | 0% | 0% | 100% |
| Pool Pumps | National Grid | 0% | 0% | 0% | 100% |
| Ref Frz Recycling | National Grid | 0% | 0% | 0% | 67% |
| Refrigerator Rebate | National Grid | 0% | 0% | 0% | 100% |
| Room AC (Upstream) | National Grid | 35% | 0% | 0% | 65% |
| Room AC (Upstream) | National Grid | 35% | 0% | 0% | 65% |
| Room Air Cleaner | National Grid | 0% | 0% | 0% | 100% |
| Smart Strips | National Grid | 0% | 0% | 0% | 100% |
| **Low-Income Residential New Construction** | | | | | |
| ENERGY STAR Appliances – Refrigerators | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR Homes – Heating, Cooling, and Water Heat Savings | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR Homes – Heating, Cooling, and Water Heat Savings | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR Homes – Heating, Cooling, and Water Heat Savings | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR Lighting – Indoor Fixtures | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR Lighting – Light–Emitting Diode Lights | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR® CFL Lamps | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR® Dishwashers | National Grid | 0% | 0% | 0% | 100% |
| **Low-Income 1-4 Family Retrofit** | | | | | |
| ENERGY STAR Appliances – Dehumidifiers | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR Appliances – Dehumidifiers | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Appliance Removal | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Basic Educational Measures | National Grid | 0% | 0% | 0% | 100% |
| Low Income – DHW Measures (Electric) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Electric Weatherization | National Grid | 0% | 0% | 0% | 100% |
| Low Income – ENERGY STAR® CFL Bulbs | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Freezers | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Heating System Replacement (Oil) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Oil and Gas DHW Measures (Oil and Gas) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Oil and Gas DHW Measures (Oil and Gas) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Oil Weatherization | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Refrigerators | National Grid | 0% | 0% | 0% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| Low Income – Torchieres | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Waterbed Mattress Replacement | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Window AC Replacement | National Grid | 0% | 0% | 0% | 100% |
| **Low-Income MultiFamily Retrofit** | | | | | |
| ENERGY STAR Appliances – Smart Strips | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR® Refrigerators (Retrofit) | National Grid | 0% | 0% | 0% | 100% |
| ENERGY STAR® Refrigerators (Retrofit) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Basic Educational Measures | National Grid | 0% | 0% | 0% | 100% |
| Low Income – DHW Measures (Electric) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Electric Weatherization | National Grid | 0% | 0% | 0% | 100% |
| Low Income – ENERGY STAR® CFL Bulbs | National Grid | 0% | 0% | 0% | 100% |
| Low Income – ENERGY STAR® CFL Fixtures | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Freezers | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Heating System Replacement (Oil) | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Torchieres | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Waterbed Mattress Replacement | National Grid | 0% | 0% | 0% | 100% |
| Low Income – Window AC Replacement | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Air Sealing | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Air Sealing | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – DHW (Showerheads and Aerators) | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – DHW (Showerheads and Aerators) | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – DHW (Tank and Pipe Wrap) | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – DHW (Tank and Pipe Wrap) | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Fixtures and CFLs | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Fixtures and CFLs | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Fixtures and CFLs | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Fixtures and CFLs | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Heat Pump Tune-Up | National Grid | 3% | 0% | 0% | 97% |
| Multifamily – Insulation (Walls, Roof, Floor) | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Insulation (Walls, Roof, Floor) | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Refrigerators and Freezers | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Refrigerators and Freezers | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Thermostats | National Grid | 0% | 0% | 0% | 100% |
| Multifamily – Thermostats | National Grid | 0% | 0% | 0% | 100% |

* The Net-to-Gross factors for Residential Lighting CFL measures are accounted for in the In Service Rate factor.

## EVALUATIONS

- ENERGY STAR® Lighting: Impact Evaluation for MA, RI, and VT Residential Lighting Program Study, 2004 and the Massachusetts Energy Star Lighting Evaluation.[503]
- MassSAVE: National Grid bases the NTG factors on the Multi Year Evaluation of the MA Home Energy Service Program, Process Evaluation Summary Report, 2004 and the 2010 Net-to-Gross Home Energy Assessment Report.[504]

[503] NMR (2011). *Massachusetts ENERGY STAR ® Lighting Program: 2010 Annual Report.* Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council. Study 8 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.

| 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 | 16% | 29% | 0% | 113% |
| Lighting Controls | National Grid | 33% | 29% | 0% | 96% |
| Lighting Systems | National Grid | 33% | 29% | 0% | 96% |
| Demand Control Ventilation (DCV) | National Grid | 26% | 2% | 0% | 75% |
| Dual Enthalpy Economizer Controls (DEEC) | National Grid | 26% | 2% | 0% | 75% |
| ECM Fan Motors | National Grid | 26% | 2% | 0% | 75% |
| HE Chiller | National Grid | 26% | 2% | 0% | 75% |
| Single-Package and SS Heat Pump Systems | National Grid | 29% | 2% | 0% | 73% |
| Single-Package and SS Unitary air conditioners | National Grid | 29% | 2% | 0% | 73% |
| HE Air Compressor | National Grid | 32% | 0% | 2% | 70% |
| Refrigerated Air Dryers | National Grid | 32% | 0% | 2% | 70% |
| Premium Efficiency Motors (Failed/Stock) | National Grid | 11% | 0% | 8% | 97% |
| Premium Efficiency Motors (New) | National Grid | 14% | 3% | 8% | 97% |
| Variable Frequency Drives | National Grid | 25% | 0% | 8% | 82% |
| Custom | National Grid | 16% | 29% | 0% | 113% |
| **C&I Large Retrofit** | | | | | |
| Lighting Controls | National Grid | 17% | 13% | 0% | 96% |
| Lighting Systems | National Grid | 17% | 13% | 0% | 96% |
| Energy Management System (EMS) | National Grid | 11% | 4% | 0% | 93% |
| Hotel Occupancy Sensors | National Grid | 11% | 4% | 0% | 93% |
| Vending Machine and Cooler Controls | National Grid | 11% | 4% | 0% | 93% |
| HE Air Compressor | National Grid | 23% | 0% | 2% | 78% |
| Variable Frequency Drives | National Grid | 10% | 7% | 8% | 104% |
| Custom | National Grid | 14% | 8% | 1% | 95% |
| **C&I Small Retrofit** | | | | | |
| Lighting Controls | National Grid | 5% | 1% | 0% | 96% |
| Lighting Systems | National Grid | 5% | 1% | 0% | 96% |
| Programmable Thermostats | National Grid | 2% | 2% | 0% | 100% |
| Case Motor Replacement | National Grid | 2% | 2% | 0% | 100% |
| Cooler Night Covers | National Grid | 2% | 2% | 0% | 100% |
| Cooler/Freezer Door Heater Control | National Grid | 2% | 2% | 0% | 100% |
| Cooler/Freezer Evaporator Fan Controls | National Grid | 2% | 2% | 0% | 100% |
| ECM for Evaporator Fans in Walk-in Coolers and Freezers | National Grid | 2% | 2% | 0% | 100% |
| Electronic Defrost Control | National Grid | 2% | 2% | 0% | 100% |
| LEDs in Freezers/Coolers | National Grid | 2% | 2% | 0% | 100% |
| Novelty Cooler Shutoff | National Grid | 2% | 2% | 0% | 100% |

**EVALUATIONS**

- All factors are from the Massachusetts C&I Electric Net-to-Gross Study.[505]

[504] 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.

[505] Tetra Tech, Inc. (2011). *2010 Commercial and Industrial Electric Programs Free-ridership and Spillover Study.* The Electric and Gas Program Administrators of Massachusetts. Study 30 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.

| Residential Natural Gas Measures | | | | | |
|---|---|---|---|---|---|
| **Measure** | **PA** | **FR** | **$SO_P$** | **$SO_{NP}$** | **NTG** |
| **Residential New Construction & Major Renovation** | | | | | |
| Refrigerators | National Grid | 0% | 0% | 0% | 100% |
| ES Homes - Cooling | National Grid | 0% | 0% | 0% | 100% |
| ES Homes - Heating | National Grid | 0% | 0% | 0% | 100% |
| ES Homes - Water Heating | National Grid | 0% | 0% | 0% | 100% |
| Indoor Fixture | National Grid | 0% | 0% | 0% | 100% |
| LED Fixture | National Grid | 0% | 0% | 0% | 100% |
| Screw-in Bulbs | National Grid | 0% | 0% | 0% | 100% |
| Clothes Washers | National Grid | 0% | 0% | 0% | 100% |
| Dishwashers | National Grid | 0% | 0% | 0% | 100% |
| **Residential Heating and Water Heating** | | | | | |
| Boiler (AFUE >= 85%) | National Grid | 69% | 14% | 0% | 45% |
| Boiler (AFUE >= 90%) | National Grid | 60% | 14% | 0% | 54% |
| Boiler Reset Controls | National Grid | 0% | 0% | 0% | 100% |
| Condensing Water Heater | National Grid | 37% | 0% | 0% | 63% |
| Early Replacement Boiler (Retirement Value) | National Grid | 0% | 0% | 0% | 100% |
| Early Replacement Boiler (HE Value) | National Grid | 0% | 0% | 0% | 100% |
| ES Programmable Thermostats | National Grid | 58% | 0% | 0% | 42% |
| Furnace w/ ECM (AFUE = 92%) | National Grid | 62% | 19% | 0% | 57% |
| Furnace w/ ECM (AFUE = 94%) | National Grid | 62% | 19% | 0% | 57% |
| Heat Recovery Ventilator | National Grid | 0% | 0% | 0% | 100% |
| Indirect Water Heater | National Grid | 66% | 0% | 0% | 34% |
| Integrated water heater/condensing boiler | National Grid | 60% | 14% | 0% | 54% |
| Integrated water heater/non-condensing boiler | National Grid | 69% | 14% | 0% | 45% |
| Stand Alone Storage Water Heater (EF >= 0.62) | National Grid | 37% | 0% | 0% | 63% |
| Tankless Water Heaters (EF >= 0.82) | National Grid | 63% | 0% | 0% | 37% |
| **OPOWER Program** | | | | | |
| CUSTSERV | National Grid | 0% | 0% | 0% | 100% |

## EVALUATIONS

All NTG factors are set to 100% based on no completed evaluations, unless noted otherwise below.

- Residential Heating and Water Heating: Free-ridership rates are based on the results of the 2011 impact evaluation for measures that were included in that study. [506] 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.[507]

[506] 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.
[507] Massachusetts Common Assumption.

| Commercial Natural Gas Efficiency Measures | | | | | |
|---|---|---|---|---|---|
| **TRM Measure Group** | **PA** | **FR** | **$SO_P$** | **$SO_{NP}$** | **NTG** |
| **C&I New Construction & Major Renovation** | | | | | |
| Commercial Fryers | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Griddle | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Combination Oven (>=40%) | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Convection Oven (>=40%) | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Conveyor Oven (>=40%) | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Rack Oven (>=50%) | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Steamer | National Grid | 17% | 0% | 0% | 83% |
| Condensing Stand-Alone Water Heater | National Grid | 17% | 0% | 0% | 83% |
| HE Indirect Water Heater | National Grid | 17% | 0% | 0% | 83% |
| Tankless Water Heater | National Grid | 17% | 0% | 0% | 83% |
| Condensing Unit Heaters | National Grid | 17% | 0% | 0% | 83% |
| Infrared Heaters | National Grid | 17% | 0% | 0% | 83% |
| HE Gas Boiler | National Grid | 17% | 0% | 0% | 83% |
| Furnace (AFUE >= 92%) | National Grid | 17% | 0% | 0% | 83% |
| Furnace (AFUE >= 92%) w/ECM | National Grid | 17% | 0% | 0% | 83% |
| Furnace (AFUE >= 94%) w/ECM | National Grid | 17% | 0% | 0% | 83% |
| Integrated Water Heater/Condensing Boiler (0.86 EF, 0.85 AFUE) | National Grid | 17% | 0% | 0% | 83% |
| Integrated Water Heater/Condensing Boiler (0.86 EF, 0.90 AFUE) | National Grid | 17% | 0% | 0% | 83% |
| Free Standing Water Heater | National Grid | 17% | 0% | 0% | 83% |
| **C&I Retrofit** | | | | | |
| Pre-Rinse Spray Valve | National Grid | 17% | 0% | 0% | 83% |
| Steam Traps | National Grid | 17% | 0% | 0% | 83% |
| Boiler Reset Controls | National Grid | 17% | 0% | 0% | 83% |
| ES Programmable Thermostats | National Grid | 17% | 0% | 0% | 83% |
| **C&I Direct Install** | | | | | |
| Faucet Aerators | National Grid | 17% | 0% | 0% | 83% |
| Low Flow Shower Heads | National Grid | 17% | 0% | 0% | 83% |
| Pre-Rinse Spray Valve | National Grid | 17% | 0% | 0% | 83% |
| Boiler Reset Controls | National Grid | 17% | 0% | 0% | 83% |
| ES Programmable Thermostats | National Grid | 17% | 0% | 0% | 83% |

## EVALUATIONS

All factors are from the Massachusetts C&I Gas Net-to-Gross Study.[508]

[508] NMR (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 Energy Efficiency Advisory Council. Study 11 in the 2010 Massachusetts Electric Energy Efficiency Annual Report.

# Appendix C: Acronyms

| ACRONYM | DESCRIPTION |
|---|---|
| AC | Air Conditioning |
| AFUE | Annual Fuel Utilization Efficiency (see the Glossary) |
| AHU | Air Handling Unit |
| Btu | British Thermal Unit (see the Glossary) |
| CF | Coincidence Factor (see the Glossary) |
| CFL | Compact Fluorescent Lamp |
| CHP | Combined Heat and Power |
| COP | Coefficient of Performance (see the Glossary) |
| DCV | Demand Controlled Ventillation |
| DHW | Domestic Hot Water |
| DOER | Department of Energy Resources |
| DSM | Demand Side Management (see the Glossary) |
| ECM | Electrically Commutated Motor |
| EER | Energy Efficiency Ratio (see the Glossary) |
| EF | Efficiency Factor |
| EFLH | Equivalent Full Load Hours (see the Glossary) |
| ES | ENERGY STAR® (see the Glossary) |
| FCM | Forward Capacity Market |
| FR | Free-Ridership (see the Glossary) |
| HE | High-Efficiency |
| HID | High-Intensity Discharge (a lighting technology) |
| HP | Horse Power (see the Glossary) |
| HSPF | Heating Seasonal Performance Factor (see the Glossary) |
| HVAC | Heating, Ventilating, and Air Conditioning |
| ISO | Independent System Operator |
| ISR | In-Service Rate (see the Glossary) |
| kW | Kilo-Watt, a unit of electric demand equal to 1,000 watts |
| kWh | Kilowatt-Hour, a unit of energy (1 kilowatt of power supplied for one hour) |
| LED | Light-Emitting Diode (one type of solid-state lighting) |
| LCD | Liquid Crystal Display (a technology used for computer monitors and similar displays) |
| MMBtu | One million British Thermal Units (see "Btu" in the Glossary) |
| MW | Megawatt – a measure of electric demand equal to 1,000 kilowatts |
| MWh | Megawatt-hour – a measure of energy equal to 1,000 kilowatt-hours |
| NEB | Non-Electric Benefit (see the Glossary) |
| NEI | Non-Energy Impact |
| NE-ISO | New England Independent System Operator |
| NTG | Net-to-Gross (see the Glossary) |
| O&M | Operations and Maintenance |
| PA | Program Administrator (see the Glossary) |
| PARIS | Planning And Reporting Information System (a DOER database - see the Glossary) |
| PC | Personal Computer |
| RR | Realization Rate (see the Glossary) |
| SEER | Seasonal Energy Efficiency Ratio (see the Glossary) |
| SO | Spillover (see the Glossary) |
| SPF | Savings Persistence Factor (see the Glossary) |
| SSL | Solid-State Lighting (e.g., LED lighting) |
| VSD | Variable-Speed Drive |

# Appendix D: Glossary

This glossary provides definitions as they are applied in this TRM for Massachusetts' energy efficiency programs. Alternate definitions may be used for some terms in other contexts.

| TERM | DESCRIPTION |
|---|---|
| Adjusted Gross Savings | Gross savings (as calculated by the measure savings algorithms) that have been subsequently adjusted by the application of all impact factors except the net-to-gross factors (free-ridership and spillover). For more detail, see the section on Impact Factors for Calculating Adjusted Gross and Net Savings. |
| AFUE | Annual Fuel Utilization Efficiency. The measure of seasonal or annual efficiency of a furnace or boiler. AFUE takes into account the cyclic on/off operation and associated energy losses of the heating unit as it responds to changes in the load, which in turn is affected by changes in weather and occupant controls. |
| Baseline Efficiency | The level of efficiency of the equipment that would have been installed without any influence from the program or, for retrofit cases where site-specific information is available, the actual efficiency of the existing equipment. |
| Btu | British thermal unit. A Btu is approximately the amount of energy needed to heat one pound of water by one degree Fahrenheit. |
| Coefficient of Performance (COP) | Coefficient of Performance is a measure of the efficiency of a heat pump, air conditioner, or refrigeration system. A COP value is given as the Btu output of a device divided by the Btu input of the device. The input and output are determined at AHRI testing standards conditions designed to reflect peak load operation. |
| Coincidence Factor (CF) | Coincidence Factors represent the fraction of connected load expected to occur concurrent to a particular system peak period; separate CF are found for summer and winter peaks. The CF given in the TRM includes both coincidence and diversity factors multiplied into one number. Coincidence factors are provided for peak periods defined by the NE-ISO for FCM purposes and calculated consistent with the FCM methodology. |
| Connected Load kW Savings | The connected load kW savings is the power saved by the equipment while in use. In some cases the savings reflect the maximum power draw of equipment at full load. In other cases the connected load may be variable, which must be accounted for in the savings algorithm. |
| Deemed Savings | Savings values (electric, fossil fuel and/or non-energy benefits) determined from savings algorithms with assumed values for all algorithm parameters. Alternatively, deemed savings values may be determined from evaluation studies. A measure with deemed savings will have the same savings per unit since all measure assumptions are the same. Deemed savings are used by program administrators to report savings for measures with well-defined performance characteristics relative to baseline efficiency cases. Deemed savings can simplify program planning and design, but may lead to over- or under-estimation of savings depending on product performance. |
| Deemed Calculated Savings | Savings values (electric, fossil fuel and/or non-energy benefits) that depend on a standard savings algorithm and for which at least one of the algorithm parameters (e.g., hours of operation) is project specific. |
| Demand Savings | The reduction in demand due to installation of an energy efficiency measure, usually expressed as kW and measured at the customer's meter (see Connected Load kW Savings). |
| Demand Side Management (DSM) | Strategies used to manage energy demand including energy efficiency, load management, fuel substitution, and load building. |
| 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:<br>ALght Lighting HEUBe Behavior<br>HVAC HVAC Ienvl Insulation & Air Sealing<br>CMoDr Motors & Drives JGchp Combined Heat & Power<br>DRefr Refrigeration KSdhw Solar Hot Water<br>EHoWa Hot Water LDmdR Demand Response<br>FComA Compressed Air MPvEl Photovoltaic Panels<br>GProc Process*<br>*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:<br>• **Summer Peak**: 6am–10pm, Monday–Friday (except ISO holidays), June–September<br>• **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<br>• **Winter Peak:** 6am–10pm, Monday–Friday (except ISO holidays), January–May and October–December<br>• **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 Berkshire Gas, Blackstone Gas Company, Columbia Gas of Massachusetts, National Grid, New England Gas Company, NSTAR, and Unitil. |
| 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. |