# Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of the Program Funded Engineering Study (the Study)

## General Guidelines:

There are two approved methods for the quantification of the projected savings expected form the implementation of EMMs analyzed in the Study

1) Hand calculation of the projected savings:
    a. For any EEM which is included as a Commercial and Industrial measure in the MassSave Program Technical Reference Manual (TRM), the TRM measure-specific algorithms for primary and secondary savings should be used. A copy of the complete MassSave TRM can be downloaded at http://www.ma-eeac.org/docs/MA%20TRM_2011%20PLAN%20VERSION.PDF
    b. For Weatherization measures – see below
    c. For all other measures: Provide a detailed calculation including description, assumptions and all calculation steps.
2) Use of the eQUEST (Versions 3.64) Building Energy Simulation program to parametrically model and quantify the impact of the EEMs each of the EEMs and to provide and quantification of the projected savings for the combined effect of the recommended EEMs.
3) **Note**: In this document, the subscript $_{EE}$, is interchangeable with $_{EEM.}$

# Weatherization:

## Added Thermal Insulation:

**Description:** Provides enhanced thermal insulation of walls, roofs, floors, doors and windows.

MMBTU Savings:

$\Delta MMBTU = MMBTU_{BASE} - MMBTU_{EEM}$

*Where*

$MMBTU = \{(U_1A_1 + U_2A_2 .... + U_nA_n)(DD) \times 24\}/1{,}000{,}000$

*For the tornado affected region:* $DD_{HEATING} = 6707$, $DD_{COOLING} = 453$; *and*

$\mathbf{MMBTU_{HEATING} = (U_1A_1 + U_2A_2 .... + U_nA_n)(160968)/ 1{,}000{,}000}$

$\mathbf{MMBTU_{COOLING} = (U_1A_1 + U_2A_2 .... + U_nA_n)(10872)/ 1{,}000{,}000}$

*Where*:

U = U-value, which is the combined heat transfer coefficient of the building envelope element to be replaced (e.g. Windows, Exterior wall section, Roof). Units are (kBtu/ sf •Deg. F•hr).
**Note**: For insulating values listed as R-values, the U-value = (1/R-value)

A = Total area of the envelope element to be replaced.

$DD_{HEATING}$ = The annual number of heating degree days (base interior temperature = 65 °F)

$DD_{COOLING}$ = he annual number of cooling degree days (base interior temperature = 65 °F)

BASE= For computing total savings, BASE = Existing condition and/or system . For computing incremental savings, BASE = Compliant with current effective Mass Energy Building Code (2009 IEEC)

## TRM-based Calculation of Savings for selected EEMs :

The generic form of the TRM formulae for quantifying projected electric and gas savings resulting from EEMs are:

For Electric Savings:

$$\Delta kWh = (\Delta kW)(Hours)$$

$$\Delta kW = (Watts_{Base} – Watts_{EEM}) / 10000$$

*Where*

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

$Watts_{EEM}$ = EEM connected kW

For Gas, Oil or other Fuel Savings:

$$\Delta Therms= (\Delta Therms/hr)( Hours)$$

$$\Delta MMBTU/Hour = (BTU/hr_{Base} – BTU/hr_{EEM}) / 100,000,000$$

*Where*

ΔTherms = gross annual Therms savings from the measure

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**For both Electric and Gas, Oil Savings for EEMs included in the Study:**

For computing total savings, BASE = Existing condition and/or system

For computing incremental savings, BASE = Compliant with current effective Mass Energy Building Code (2009 IEEC)

***TRM EEMs for which Electric Savings are Primary***

### Lighting – Advanced Lighting Design (Performance Lighting)

**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.

Electric Savings:

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

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

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 12 and Appendix A: Table 13.

$Watts_{EE,i}$ = installed lighting wattage per square foot of the efficient lighting system for building or space type *i*.

1000 = watts per 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 (see **Error! Reference source not ound.**).

## 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 only 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.[1] Table 12 and Table 13 in**Error! Reference source not found.** detail the specific power requirements by compliance path.

## High Efficiency

The high efficiency scenario assumes lighting systems that achieve lighting power densities below those required by Massachusetts State Building Code. Actual site lighting power densities should be determined on a case-by-case basis. Please refer to the current year application form for minimum percentage better than code efficiency requirements.

## Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis. If site-specific hours are unavailable, refer to the default hours in Appendix A: **Error! eference source not found.**.

[1] 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.

# ReBuild Western Massachusetts

## Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

Measure Life

| Measure | Measure Life [2] |
|---|---|
| Fluorescent Fixture | 15 years |
| Hardwired CFL | 15 years |
| LED Exit Signs | 15 years |
| HID (interior and exterior) | 15 years |

Gas Savings

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.

**Note for this EEM the gas savings is a negative quantity**

| Measure | Energy Type | Impact[3] |
|---|---|---|
| Interior Lighting | C&I Gas Heat | -0.001277 MMBtu/ΔkWh |
| Interior Lighting | Oil | -0.002496 MMBtu/ΔkWh |

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

[3] Optimal Energy, Inc. (2008). *Non-Electric Benefits Analysis Update*. Memo Prepared for National Grid.

## ReBuild Western Massachusetts

### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

## Lighting – Lighting Systems

**Description:** This measure promotes the installation of efficient lighting systems. Promoted technologies include, but are not limited to, efficient fluorescent lamps, ballasts, and fixtures, solid state lighting, and efficient high intensity discharge (HID) lamps, ballasts, and fixtures.

Electric Savings:

$$\Delta kWh = \left[ \sum_{i=1}^{n} \left( \frac{Count_i * Watts_i}{1000} \right)_{BASE} - \sum_{j=1}^{m} \left( \frac{Count_j * Watts_j}{1000} \right)_{EE} \right] (Hours)$$

$$\Delta kW = \sum_{i=1}^{n} \left( \frac{Count_i * Watts_i}{1000} \right)_{BASE} - \sum_{j=1}^{m} \left( \frac{Count_j * Watts_j}{1000} \right)_{EE}$$

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 (for retrofit, use the existing fixture wattage; for lost-opportunity, refer to the New Construction baseline wattage tables) |
| $Count_j$ | = | quantity of efficient fixtures of type j. |
| $Watts_j$ | = | efficient fixture wattage for fixture type j. See MassSAVE Wattage Tables[4] |
| 1000 | = | watts per kW. |
| Hours | = | lighting annual hours of operation. |

Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates (See Impact Factors section).

[4] MassSAVE Retrofit and New Construction Lighting Wattage Tables

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### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

Baseline Efficiency

For retrofit installations, the baseline is project-specific and is determined using actual fixture counts from the existing space. Existing fixture wattages are provided in the MassSAVE Wattage Tables[5].

For new construction installations, the baseline is determined using assumed baseline wattages for each of the installed fixtures[6].

**Note: For replacement of tornado- damaged fixtures – use the baseline for new construction installations.**

High Efficiency

For both new construction and retrofit installations, the high efficiency case is project-specific and is determined using actual fixture counts for the project and the MassSAVE Wattage Tables[7].

Hours

The annual hours of operation for lighting systems are site-specific and should be determined on a case-by-case basis. If site-specific hours of operation are unavailable, refer to the default hours presented in Appendix A: **Error! Reference source not found.**.

Gas Savings

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.

**Note for this EEM the gas savings is a negative quantity**

| Measure | Energy Type | Savings[8] |
|---|---|---|
| Interior Lighting | C&I Gas Heat | -0.001277 MMBtu/kWh |

[5] MassSAVE Retrofit and New Construction Lighting Wattage Tables
[6] MassSAVE New Cosntruction Lighting Baseline Wattage Tables
[7] Ibid.
[8] Optimal Energy, Inc. (2008). *Non-Electric Benefits Analysis Update*. Memo Prepared for National Grid.

## ReBuild Western Massachusetts

### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

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

**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.

Electric Savings:

For units with cooling capacities less than 65 kBtu/hr

$$\Delta kWh = (\ kBtu/hr)\ (1/SEER_{BASE} - 1/SEER_{EEM}\ ) \times EFLH_{cool}$$

$$\Delta kW = (1/EER_{BASE} - 1/EER_{EEM}\ )$$

*For units with cooling capacities greater than 65 kBtu/hr:*

$$\Delta kWh = (\ kBtu/hr)\ (1/EER_{BASE} - 1/EER_{EEM}\ ) \times EFLH_{cool}$$

$$\Delta kW = (1/EER_{BASE} - 1/EER_{EEM})$$

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
$SEER_{EEM}$ = Seasonal Energy Efficiency Ratio of the energy efficient equipment.
$EFLH_{Cool}$ = Cooling equivalent full load hours (see Appendix A Table 20 of TRM for default hours)

**Table 1: Unitary Air Conditioners Baseline Efficiency Levels**[9]

| Equipment Type | Size Category | Subcategory or Rating Condition | Baseline Efficiency |
|---|---|---|---|
| Air conditioners, air cooled | <65,000 Btu/h[b] | Split system | 13.0 SEER |
| | | Single package | 13.0 SEER |
| | ≥65,000 Btu/h and <135,000 Btu/h | Split system and single package | 11.2 EER[a] |
| | ≥135,000 Btu/h and <240,000 Btu/h | Split system and single package | 11.0 EER[a] |
| | ≥240,000 Btu/h and <760,000 Btu/h | Split system and single package | 10.0 EER[a] |
| | ≥760,000 Btu/h | Split system and single package | 9.7 EER[a] |
| Air conditioners, Water and evaporatively cooled | <65,000 Btu/h | Split system and single package | 12.1 EER |
| | ≥65,000 Btu/h and <135,000 Btu/h | Split system and single package | 11.5 EER[a] |
| | ≥135,000 Btu/h and <240,000 Btu/h | Split system and single package | 11.0 EER[a] |
| | ≥240,000 Btu/h | Split system and single package | 11.0 EER[a] |

a. Deduct 0.2 from the required EERs for units with a heating section other than electric heat[10].

b. Single-phase air-cooled air conditioners <65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

Gas Savings: Not Applicable

9 2009 International Energy Conservation Code, International Code Council, 2009, p.43, Table 503.2.3(1)
10 The PAs do not differentiate between units by heating section types. To be conservative, the highest Baseline Efficiency is assumed for all heating section types in each equipment category.

## ReBuild Western Massachusetts

### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

#### HVAC – Single Package or Split System Heat Pump Systems

**Description** : This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems.

Electric Savings:

*For air cooled units with cooling capacities less than 65 kBtu/hr:*

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/hr)\ (1/SEER_{BASE} - 1/SEER_{EEM})\ x\ EFLH_{cool}$$

$$\Delta kWh_{heat} = (kBtu/hr)\ (1/HSPF_{BASE} - 1/HSPF_{EEM})\ x\ EFLH_{heat}$$

$$\Delta kW = (1/EER_{BASE} - 1/EER_{EEM})$$

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

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = (kBtu/hr)\ (1/EER_{BASE} - 1/EER_{EEM})\ x\ EFLH_{cool}$$

$$kWh_{heat} = (kBtu/hr)\ (1/COP_{BASE} - 1/COP_{EEM})\ x\ EFLH_{heat}$$

$$\Delta\Delta kW = (1/EER_{BASE} - 1/EER_{EEM})$$

Where:

$\Delta kWh_{COOL}$ = Gross annual cooling mode kWh savings from the measure.

$\Delta kWh_{HEAT}$ = Gross annual heating mode kWh savings from the measure.

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 2 for values.

$SEER_{EEM}$= Seasonal Energy Efficiency Ratio of the energy efficient equipment.

$EFLH_{COOL}$ = Cooling mode equivalent full load hours.

$HSPF_{BASE}$ = Heating Seasonal Performance Factor of the baseline equipment. See TRM Table 2 for values.

$HSPF_{EEM}$ = Heating Seasonal Performance Factor of the energy efficient equipment.

$EFLH_{HEAT}$ = Heating mode equivalent full load hours.

$kBtu/h_{COOL}$ = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).

$EER_{BASE}$ = Energy Efficiency Ratio of the baseline equipment. See Table 2 for values. Since IECC 2009 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

$EER_{EE}$ = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual $EER_{EE}$ is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

$kBtu/h_{HEAT}$ = Capacity of the heating equipment in kBtu per hour. If the heating capacity is unknown, it can be calculated from the cooling capacity using the conversion factors defined below.

3.412 = Conversion factor: 3.412 Btu per Wh.

$COP_{BASE}$ = Coefficient of performance of the baseline equipment. See Table 2 for values.

$COP_{EE}$ = Coefficient of performance of the energy efficient equipment.

*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)

Gas Savings:– Not Applicable

**Table 2: Unitary and Applied Heat Pumps Baseline Efficiency Levels**[11]

| Equipment Type | Size Category (Cooling Capacity) | Subcategory or Rating Condition | Baseline Efficiency (Cooling Mode) | Baseline Efficiency (Heating Mode) |
|---|---|---|---|---|
| Air cooled | <65,000 Btu/h[b] | Split system | 13.0 SEER | 7.7 HSPF |
| | | Single package | 13.0 SEER | 7.7 HSPF |
| | ≥65,000 Btu/h and <135,000 Btu/h | Split system and single package / 47°F db/43°F wb outdoor air | 11.0 EER[a] | 3.3 COP |
| | ≥135,000 Btu/h and <240,000 Btu/h | Split system and single package / 47°F db/43°F wb outdoor air | 10.6 EER[a] | 3.2 COP |
| | ≥240,000 Btu/h | Split system and single package / 47°F db/43°F wb outdoor air | 9.5 EER[a] | 3.2 COP |
| Water source | <17,000 Btu/h | 86°F entering water (Cooling Mode) / 68°F entering water (Heating Mode) | 11.2 EER | 4.2 COP |
| | ≥17,000 Btu/h and <135,000 Btu/h | 86°F entering water / 68°F entering water (Heating Mode) | 12.0 EER | 4.2 COP |
| Groundwater source | <135,000 Btu/h | 59°F entering water (Cooling Mode) / 50°F entering water (Heating Mode) | 16.2 EER | 3.6 COP |
| Ground source | <135,000 Btu/h | 77°F entering water / 32°F entering water (Heating Mode) | 13.4 EER | 3.1 COP |

db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.

a. Deduct 0.2 from the required EERs for units with a heating section other than electric heat[12].

[11] 2009 International Energy Conservation Code, International Code Council, 2009, p.44, Table 503.2.3(2)

[12] The PAs do not differentiate between units by heating section types. To be conservative, the highest Baseline Efficiency is assumed for all heating section types in each equipment category.

## ReBuild Western Massachusetts

### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

### HVAC – Dual Enthalpy Economizer Controls (DEEC)

**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.

Electric Savings:

$$\Delta kWh = (kBtu/hr)(\ 1\ Ton\ /12\ kBtu/hr)\ )SAVE_{kwh}$$

$$\Delta kW = (kBtu/hr)(\ 1\ Ton\ /12\ kBtu/hr)\ )SAVE_{kw}$$

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
$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.289 kW/ton

**Baseline Efficiency**
The baseline efficiency case for this measure assumes the relevant HVAC equipment is operating with a fixed dry-bulb economizer.

**EEM Case**
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.

### HVAC – Demand Control Ventilation (DCV)

**Description:** The measure 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.

Electric Savings:

$$\Delta kWh = (kBtu/hr)(\ 1\ Ton\ /12\ kBtu/hr)\ )SAVE_{kwh}$$

$$\Delta kW = (kBtu/hr)(\ 1\ Ton\ /12\ kBtu/hr)\ )SAVE_{kw}$$

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

$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.15 kW/ton

**Baseline Efficiency**

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

**EEM Case**

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

Gas, Oil Savings

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:

Gas Savings: = 0.001277 MMBtu/kWh
Oil Savings = 0.002496 MMBtu/kWh

## HVAC – ECM Fan Motors

**Description**: The installation of electronically commutated motors (ECMs) on fan powered terminal boxes, fan coils, and HVAC supply fans on small unitary equipment.

Gas, Oil Savings: Not Applicable
Electric Savings:

$$kWh = (Design\ CFM)(Box\ Size\ Factor)(\%\ Flow_{ANNUAL})(Hours)$$

$$kWh_{SP} = (Design\ CFM)(Box\ Size\ Factor)(\%Flow_{SP})$$

$$kWh_{WP} = (Design\ CFM)(Box\ Size\ Factor)(\%Flow_{WP})$$

Where:

Design CFM = capacity of the VAV box in cubic feet per minute

Box Size Factor = Savings factor in Watts/CFM. See **Table 3** for values.

$\%Flow_{ANNUAL}$ = Average % of design flow over all operating hours. See **Table 3** for values.

$\%Flow_{SP}$ = Average % of design flow during summer peak period. See **Table 3** for values.

$\%Flow_{WP}$ = Average % of design flow during summer peak period. See **Table 3** for values.

Hours = annual operating hours for VAV box fans

**Table 3: ECM Fan Motor Savings Factors**

| 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 for this measure assumes the VAV box fans are powered by a single speed fractional horsepower permanent split capacitor (PSC) induction motor.

EEM Case

Motor must be installed on new, qualifying HVAC equipment.

## HVAC – High Efficiency Chiller

**Description:** 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.

Gas, Oil Savings: Not Applicable

Electric Savings:

*Air-Cooled Chillers:*

$$\Delta kWh = (Tons)\left(\frac{12}{EER_{BASE}} - \frac{12}{EER_{EE}}\right)(Hours)$$

$$\Delta kW = (Tons)\left(\frac{12}{EER_{BASE}} - \frac{12}{EER_{EE}}\right)(CF)$$

*Water-Cooled Chillers:*

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

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

Where:

| | | |
|---|---|---|
| Tons | = | Rated capacity of the cooling equipment |
| $EER_{BASE}$ | = | Energy Efficiency Ratio of the baseline equipment. See Table 4 for values. |
| $EER_{EE}$ | = | Energy Efficiency Ratio of the efficient equipment. See Table 4 for values. |
| $kW/ton_{BASE}$ | = | Energy Efficiency rating of the baseline equipment. See Table 4 for values. |
| $kW/ton_{EE}$ | = | Energy Efficiency rating of the efficient equipment. See Table 4 for values. |
| Hours | = | Equivalent full load hours for chiller operation |
| LF | = | Load Factor |

Baseline Efficiency

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. Both documents present consistent requirements for water chilling packages.

Table **4** details the specific efficiency requirements by equipment type and capacity.

**Table 4: Water Chilling Packages - Minimum Efficiency Requirements[13]**

| Equipment Type | Size Category | Units | Full Load | IPLV |
|---|---|---|---|---|
| Air cooled chillers | All capacities | EER | ≥ 9.562 | ≥ 10.416 |
| Water cooled, electrically operated, positive displacement (rotary screw and scroll) | < 150 tons | kW/ton | ≤ 0.790 | ≤ 0.676 |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.717 | ≤ 0.627 |
| | ≥ 300 tons | kW/ton | ≤ 0.639 | ≤ 0.571 |
| Water cooled, electrically operated, centrifugal | < 150 tons | kW/ton | ≤ 0.703 | ≤ 0.669 |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.634 | ≤ 0.596 |
| | ≥ 300 tons | kW/ton | ≤ 0.576 | ≤ 0.549 |

<u>EEM Case</u>

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.

### HVAC – Programmable Thermostats

**Description:** The installation of a programmable thermostat for cooling and/or heating systems in spaces with either no or erratic existing control.

<u>Gas, Oil Savings: See separate Gas Measures EEM Gas</u>

<u>Electric Savings:</u>

$$\Delta kWh = (SQFT)\ (SAVE_{kWh})$$
$$\Delta kW = (SQFT)\ (SAVE_{kW})$$

[13] These are the "Before 1/1/2020" minimum efficiency values from "2009 IECC, Table 503.2.3(7): Water Chilling Packages, Efficiency Requirements".

Where:
SQFT = Square feet of controlled space
SAVEkWh = Average kW reduction per SQFT of controlled space. See Table 5.
SAVEkW = Average annual kWh reduction per SQFT of controlled. See Table 5.

**Table 5: Savings Factors (SAVE)**

| 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 for this measure includes spaces with either no or erratic heating and/or cooling control as indicated in the equipment type selection.

## Refrigeration – Door Heater Controls

**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.

Gas, Oil Savings: Not Applicable
Electric Savings:

$$\Delta kWh = kW_{DH} * \%OFF * 8760$$

$$\Delta kW = kW_{DH} * \%OFF$$

Where:

$kW_{DH}$ = Total demand of the door heater, calculated as Volts * Amps / 1000

8760 = Door heater annual run hours before controls

%OFF Door heater Off time (46% for freezer door heaters; 74% for cooler door heaters)

Baseline Efficiency

The baseline case for this measure 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$^{o}$F above the store air dewpoint temperature with the heaters operating at 80% on (adjustable).

### *TRM EEMs for which Gas or Oil Savings are Primary*

### HVAC – ENERGY STAR® Programmable Thermostat

**Description:** Ability to adjust heating or air-conditioning operating times according to a pre-set schedule to meet occupancy needs and minimize redundant HVAC operation.

Electric Savings: Not Applicable

Gas, Oil Savings:

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:

Unit = Installed programmable thermostat

ΔMMBtu = Average annual MMBtu reduction per unit: 7.7

Baseline Efficiency

The baseline efficiency case is an HVAC system using natural gas or oil to provide space heating without a programmable thermostat.

EEM Case

The EEM case is an HVAC system using natural gas to provide space heating with an ENERGY STAR® Programmable Thermostat installed.

### HVAC – Condensing Unit Heater

**Description:** Installation of a Condensing Gas Fired Unit Heater for space heating with capacity of 151 – 400 MBH and minimum combustion efficiency of 90%

Electric Savings: Not Applicable

Gas Savings:

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

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.

EEM Case

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

### HVAC – High Efficiency Natural Gas Boiler

**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.

Gas Savings:

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 6 for values.

**Table 6: MMBtu Savings by Boiler Type**

| Boiler Type/Size | ΔMMBTU |
|---|---|
| Steam Boiler 82% AFUE or greater | 36.5 |
| Condensing Boiler <=300 MBH - 90% AFUE or greater | 32.3 |
| Condensing Boiler 301-499 MBH - 90% thermal efficiency or greater | 78.3 |
| Condensing Boiler 500-999 MBH - 90% thermal efficiency or greater | 146.7 |
| Condensing Boiler 1000-1700 MBH - 90% thermal efficiency or greater | 264.1 |
| Condensing Boiler 1701+ MBH - 90% thermal efficiency or greater | 332.6 |
| 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 |

### 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 **7** below details the specific efficiency requirements by equipment type and capacity.

**Table 7: Boilers, Gas-Fired, Minimum Efficiency Requirements**

| 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

EEM Case

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.

## HVAC – High Efficiency Natural Gas Warm Air Furnace

**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.

Electric Savings: Not Applicable

Gas Savings:

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 8 for values.

**Table 8: MMBtu Savings by Furnace Type**

| Boiler Type/Size | ΔMMBTU |
|---|---|
| Furnace AFUE => 92% | 21.1 |
| Furnace AFUE => 92% w/ ECM | 19. |
| 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 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 **9** details the specific efficiency requirements by equipment type and capacity.

**Table 9: Warm Air Furnaces and Combination Warm Air Furnace/Air-Conditioning Units, Warm Air Duct Furnaces, Minimum Efficiency Requirements**

| 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.

EEM Case

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.

### HVAC/Hot Water – Combined High Efficiency Boiler and Water Heater

**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.

Electric Savings: Not Applicable

Gas Savings:

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 10 for values.

**Table 10: MMBtu Savings by Boiler/Water Heater Combo Type**

| 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 case is a standard efficiency gas-fired storage tank hot water heater with a separate standard efficiency boiler for space heating purposes.

EEM Case

The high efficiency case is an condensing, integrated water heater/boiler with an AFUE of >=90% or >=85.

### Hot Water – Condensing Stand-Alone Water Heater

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

Electric Savings: Not Applicable

Gas Savings:

Unit savings are deemed based on study results:

$$\Delta MMBtu = \Delta MMBtu$$

Where:

Unit = Installed condensing stand-alone water heater

= Average annual MMBtu savings per unit (75,000 – 300,000 BTU) installed: 25.0

ΔMMBtu

Baseline Efficiency

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

EEM Case

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.

### Hot Water – High Efficiency Indirect Water Heater

**Description:** The installation of a high-efficiency indirect water heater. Indirect water heaters use a storage tank that is heated by the main furnace or boiler. The energy stored by the water tank allows the furnace to turn off and on less often, saving considerable energy.

Gas Savings:

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

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.

EEM Case

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

### Hot Water – High Efficiency Tankless Water Heater

**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 furnace or boiler to be heated for immediate use, eliminating the standby heat loss associated with a storage tank

Electric Savings: Not Applicable

Gas Savings:

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

<u>Baseline Efficiency</u>

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.

<u>EEM Case</u>

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

### Hot Water – High Efficiency Free Standing Water Heater

**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.

Electric Savings: Not Applicable

<u>Gas Savings:</u>

Unit savings are deemed based on study results:

$\Delta MMBtu = \Delta MMBtu$ here:

Unit = Installed high efficiency free-standing water heater

ΔMMBtu = Average annual MMBtu savings per unit: 0.76

<u>Baseline Efficiency</u>

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.

EEM Case

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

### Food Service – Commercial Gas-Fired Oven

**Description:** Installation of High Efficiency Gas Ovens

Electric Savings: Not Applicable

Gas Savings:

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 11 for values.

**Table 11: Baseline and High Efficiency Ratings and MMBtu Savings by Oven Type**

| Oven Type | Baseline Efficiency | High Efficiency | ΔMMBTU |
|---|---|---|---|
| High Efficiency Gas Convection Oven | 30% | >= 40% | 24.8 |
| 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 case is a standard efficiency oven. See Table 11 for values by oven type.

EEM Case

High efficiency case is an oven that meets or exceeds the high efficiency ratings per oven type shown in Table 11

## ReBuild Western Massachusetts

### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

### Food Service – Commercial Gas-Fired Griddle

**Description:** Installation of a gas griddle with an efficiency of 38%.

Electric Savings: Not Applicable

Gas Savings:

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

Baseline Efficiency

The baseline efficiency case is a standard efficiency (30% efficient) gas griddle.

EEM Case

The high efficiency case is a gas griddle with an efficiency of 38%.

### Food Service – Commercial Fryer

**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.

Electric Savings: Not Applicable

Gas Savings:

$$\Delta MMBtu = \left[\left(\frac{A_{BASE}}{\eta_{BASE}} + \left(B_{BASE} \times IDLE_{BASE}\right) + C_{BASE}\right) - \left(\frac{A_{EE}}{\eta_{EE}} + B_{EE}\left(IDLE_{EE}\right) + C_{EE}\right)\right]\left(\frac{365}{1{,}000{,}000}\right)$$

Where:

Unit = Installed high efficiency gas commercial fryer

| | | |
|---|---|---|
| ΔMMBtu | = | gross annual average MMBtu savings per unit: 58.6 |
| $A_{BASE}$ | = | 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.

EEM Case

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.

### Food Service – Commercial Gas-Fired Steamer

**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.

Electric Savings: Not Applicable

Gas Savings:

$$\Delta MMBtu = (PANS) \times (SAVE)$$

Where:

Unit = Installed high efficiency gas-fired steamer

ΔMMBtu = Average annual MMBTU savings for default condition of three pans: 153.6

PANS = efficient equipment number of pans. Default is 3 pans.

SAVE = savings per pan (MMBtu). Default SAVE = 51.2 MMBtu.

### Baseline Efficiency

The baseline efficency 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%.

### EEM Case

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 = 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%.

## Common Lookup Tables Relevant to the EEMs Listed Above (Extracted from TRM Appendix A)

**Table 12: Lighting Power Densities Using the Building Area Method ($WATTS_{b,i}$)[14]**

| 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 |

[14] IECC 2009 Lighting Provisions, Section 505 Electrical Power and Lighting Systems, Table 505.5.2 Interior Lighting Power Allowances, Lighting provisions pgs.5-6.

| Building Area Type | Lighting Power Density (W/ft$^2$) |
|---|---|
| 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 |

| Building Area Type | Lighting Power Density (W/ft$^2$) |
|---|---|
| Town Hall | 1.1 |
| Transportation | 1.0 |
| Warehouse | 0.8 |
| Workshop | 1.4 |

**Table 13: Lighting Power Densities Using the Space-by-Space Method ($WATTS_{b,i}$)[15]**

| Common Space Types | Lighting Power Density (W/ft$^2$) |
|---|---|
| Office – Enclosed | 1.1 |
| Office - Open Plan | 1.1 |
| Conference/Meeting/Multipurpose | 1.3 |
| Classroom/Lecture/Training | 1.4 |
| For Penitentiary | 1.3 |
| Lobby | 1.3 |
| For Hotel | 1.1 |
| For Performing Arts Theater | 3.3 |
| For Motion Picture Theater | 1.1 |
| Audience/Seating Area | 0.9 |
| For Gymnasium | 0.4 |
| For Exercise Center | 0.3 |
| For Convention Center | 0.7 |
| For Penitentiary | 0.7 |
| For Religious Buildings | 1.7 |

[15] 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$^2$) |
|---|---|
| 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 |

| Common Space Types | Lighting Power Density (W/ft$^2$) |
|---|---|
| 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 |
| 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 | |

| Common Space Types | Lighting Power Density (W/ft$^2$) |
|---|---|
| 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 |

| Common Space Types | Lighting Power Density (W/ft$^2$) |
|---|---|
| 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 | |
| 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 |

**ReBuild Western Massachusetts**

**Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)**

## ReBuild Western Massachusetts

### Guidelines for the Calculation of Savings for Energy Efficiency Measures (EEMs) in the Preparation of Program Funded Engineering Study (the Study)

Values for use when site-specific hours are not available.

| Building Type | Annual Operating Hours |
|---|---|
| Assembly | |
| Automobile | |
| Big Box | |
| Community College | 3255 |
| Dormitory | |
| Fast Food | 5110 |
| Full Service Restaurant | 5110 |
| Grocery | 6074 |
| Heavy Industrial | |
| Hospital | 8036 |
| Hotel | 8583 |
| Large Refrigerated Space | |
| Large Office | 3610 |
| Light Industrial | |
| Motel | 8583 |
| Multi Story Retail | 4089 |
| Multifamily high-rise | |
| Multifamily low-rise | |
| Other | 3951 |
| Religious | |
| K-12 Schools | 2596 |
| Small Office | 3610 |

| Building Type | Annual Operating Hours |
|---|---|
| Small Retail | 4089 |
| University | 3255 |
| Warehouse | 3759 |

**Table 14: Cooling Equivalent Full Load Hours by Building (or Space) Type**

**Comment [STB1]:** I assume this will be combined with the following table. If so, the references to this table should first be changed to point to the following (more detailed) table. Then this table can be deleted.

| Building (or Space) Type | Cooling Full Load Hours (EFLH) |
|---|---|
| College | 542 |
| Convenience | 3653 |
| Fast-Food, 1-Meal | 1810 |
| Fast-Food, 2-Meals | 2072 |
| Fast-Food, 3-Meals | 2295 |
| Grocery | 1299 |
| Hospital | 1575 |
| Hotel | 766 |
| Motel | 900 |
| Nursing Home | 898 |
| Office, Large | 1125 |
| Office, Medium | 660 |
| Office, Small | 953 |
| Public Assembly | 1044 |
| Religious Worship | 495 |
| Restaurant, 1-Meal | 969 |
| Restaurant, 2-Meals | 1081 |

| Building (or Space) Type | Cooling Full Load Hours (EFLH) |
|---|---|
| Restaurant, 3-Meals | 1210 |
| Retail, Large | 762 |
| Retail, Small | 1047 |
| School | 538 |
| Service | 520 |
| Warehouse, Non Refrig. | 746 |
| Warehouse, Refrig. | 775 |
| Other[16] | 777 |

## Relevant Tables from TRM Appendix A

**Table 15: Cooling and Heating Equivalent Full Load Hours by Building (or Space) Type**

| Facility Type | Cooling Full Load Hours ($EFLH_{cool}$) | Heating Full Load Hours ($EFLH_{heat}$) |
|---|---|---|
| Auto Related | 837 | 1,171 |
| Bakery | 681 | 1,471 |
| Banks, Financial Centers | 797 | 1,248 |
| Church | 564 | 1,694 |
| College - Cafeteria | 1,139 | 594 |
| College - Classes/Administrative | 646 | 1,537 |
| College - Dormitory | 709 | 1,418 |
| Commercial Condos | 837 | 1,172 |
| Convenience Stores | 1,139 | 594 |
| Convention Center | 564 | 1,695 |

[16] SAIC (1998). *Impact Evaluation of the Design 2000plus Unitary HVAC Program.* Prepared for National Grid

| Facility Type | Cooling Full Load Hours ($EFLH_{cool}$) | Heating Full Load Hours ($EFLH_{heat}$) |
|---|---|---|
| Court House | 797 | 1,248 |
| Dining: Bar Lounge/Leisure | 854 | 1,140 |
| Dining: Cafeteria / Fast Food | 1,149 | 574 |
| Dining: Family | 854 | 1,140 |
| Entertainment | 564 | 1,695 |
| Exercise Center | 1,069 | 728 |
| Fast Food Restaurants | 1,139 | 594 |
| Fire Station (Unmanned) | 564 | 1,695 |
| Food Stores | 837 | 1,172 |
| Gymnasium | 646 | 1,537 |
| Hospitals | 1,308 | 270 |
| Hospitals / Health Care | 1,307 | 272 |
| Industrial - 1 Shift | 681 | 1,470 |
| Industrial - 2 Shift | 925 | 1,003 |
| Industrial - 3 Shift | 1,172 | 530 |
| Laundromats | 837 | 1,171 |
| Library | 797 | 1,248 |
| Light Manufacturers | 681 | 1,470 |
| Lodging (Hotels/Motels) | 708 | 1,418 |
| Mall Concourse | 938 | 978 |
| Manufacturing Facility | 681 | 1,470 |
| Medical Offices | 797 | 1,248 |
| Motion Picture Theatre | 564 | 1,695 |
| Multi-Family (Common Areas) | 1,306 | 273 |

| Facility Type | Cooling Full Load Hours ($EFLH_{cool}$) | Heating Full Load Hours ($EFLH_{heat}$) |
|---|---|---|
| Museum | 797 | 1,248 |
| Nursing Homes | 1,069 | 727 |
| Office (General Office Types) | 797 | 1,248 |
| Office/Retail | 797 | 1,248 |
| Parking Garages & Lots | 878 | 1,094 |
| Penitentiary | 1,022 | 817 |
| Performing Arts Theatre | 646 | 1,537 |
| Police / Fire Stations (24 Hr) | 1,306 | 273 |
| Post Office | 797 | 1,248 |
| Pump Stations | 563 | 1,696 |
| Refrigerated Warehouse | 648 | 1,533 |
| Religious Building | 564 | 1,694 |
| Residential (Except Nursing Homes) | 709 | 1,418 |
| Restaurants | 854 | 1,140 |
| Retail | 837 | 1,171 |
| School / University | 594 | 1,637 |
| Schools (Jr./Sr. High) | 594 | 1,637 |
| Schools (Preschool/Elementary) | 594 | 1,637 |
| Schools (Technical/Vocational) | 594 | 1,637 |
| Small Services | 798 | 1,247 |
| Sports Arena | 564 | 1,695 |
| Town Hall | 797 | 1,248 |
| Transportation | 1,149 | 574 |
| Warehouse (Not Refrigerated) | 648 | 1,533 |

| Facility Type | Cooling Full Load Hours ($EFLH_{cool}$) | Heating Full Load Hours ($EFLH_{heat}$) |
|---|---|---|
| Waste Water Treatment Plant | 1,172 | 530 |
| Workshop | 798 | 1,247 |