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Connecticut's Energy Efficiency Programs are funded by the Conservation Charge on customer electric bills.

# CL&P and UI Program Savings Documentation for 2008 Program Year

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# Table of Contents

# INTRODUCTION

## 1.1 BACKGROUND

### Introduction

In 1999, the State Legislature created the Energy Conservation Management Board (ECMB) to guide and assist the State's electric distribution companies in the development and implementation of cost-effective energy conservation programs and market transformation initiatives (CGS § 16-245m). The Connecticut Energy Efficiency Fund (CEEF) created by this legislation provides the financial support for ECMB-guided programs and initiatives. The Department of Public Utility Control (DPUC) is responsible for final approval of all CEEF programs. The State's energy conservation efforts, as administered by Connecticut Light & Power and United Illuminating, with guidance from the ECMB, focus on realizing the following primary objectives:

1. **Advancing the Efficient Use of Energy**

Conservation and Load Management (C&LM) programs are critical in reducing overall energy consumption and reducing load during periods of high electric demand. These programs alleviate potential electricity shortages and reduce stress on transmission lines in the State, especially in southwestern Connecticut (SWCT).

2. **Reduce Air Pollution and Negative Environmental Impacts**

C&LM programs produce environmental benefits by slowing the electricity demand growth rate, thereby avoiding emissions that would otherwise be produced by increased power generation activities. The Environmental Protection Agency regulates criteria air pollutants under the Clean Air Act's National Ambient Air Quality Standards (NAAQSs). Connecticut's conservation programs have significantly reduced two NAAQS criteria pollutants emitted in the process of generating electricity: sulfur dioxide and nitrogen oxides. Carbon dioxide and other "greenhouse gases", such as methane, are also emitted during the process. Greenhouse gases have been linked to global warming and climate change. With decreased power production resulting from declining electrical demand as a result of conservation efforts, C&LM programs reduce carbon dioxide emissions. C&LM programs, guided by the ECMB, support the State's environmental initiatives to reduce these air pollutants as well as fine particulate emissions and ozone.

3. **Promote Economic Development and Energy Security**

Energy efficiency programs generate considerable benefits for Connecticut customers. Conservation programs are tailored to meet the particular needs of all customer classes, thereby benefiting all State residents. Energy efficiency measures assist low-income customers in reducing their energy costs, which typically comprise a significant percentage of their household income. Other groups that benefit from energy conservation programs include educational institutions, manufacturers, non-profit organizations, residential customers and small businesses. Conservation programs made possible by the CEEF lower operating costs and improve efficiency, which increases the productivity of manufacturing processes for small and large businesses. By reducing operating costs and enhancing productivity, Connecticut businesses remain competitive in the dynamic global economy, avoiding unnecessary outsourcing of jobs and services. The retention of Connecticut businesses enhances the perception among potential businesses and investors that Connecticut's economy is healthy and productive.

Information regarding Connecticut's energy conservation programs is available at:

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|---|---|
| The Connecticut Light and Power Company: | www.cl-p.com |
| The United Illuminating Company: | www.uinet.com |
| Conservation Program hot line (CL&P and UI): | 1-877-WISE USE |

The Energy Conservation Management Board:
http://www.state.ct.us/dpuc/ecmb/boardprocess.html

**Purpose**

This manual provides detailed, comprehensive documentation of all claimed resource costs and savings corresponding to individual C&LM technologies. This Program Savings Documentation (PSD) manual fulfills the Department's requirement to develop a Technical Reference Manual (Docket NO. 03-11-01PH02, DPUC Review of CL&P and UI Conservation and Load Management Plan for Year 2004 – Phase II, July 28, 2004).

Public Act 05-01, June (2005) Special Session, "An Act Concerning Energy Independence" (the "Act") established a class III requirement for electric suppliers and electric distribution companies. Following the passage of the Act, the DPUC held a proceeding to develop class III standards (Docket NO. 05-07-19, DPUC Proceeding to Develop a New Distributed Resource Portfolio Standard (Class III)). Based on the DPUC Final Decision in that Docket, the C&LM fund program's technical reference manual must be used as the basis to calculate energy efficiency for both C&LM and non-C&LM measures that qualify for Class III credits. As a result, C&LM and non-C&LM measures will be measured using the same baseline and parameters. The exception is that non-C&LM funded projects shall not incorporate free-ridership and spillover because these factors are specific to C&LM program savings, however, other impact factors (i.e. other realization rates) that are part of the energy savings calculations and methodologies must be incorporated into Class III savings calculations.

In June 2006, FERC approved a settlement that establishes a redesigned wholesale electric capacity market in New England designed to encourage the maintenance of current power plants and construction of new generation facilities. The settlement established a Forward Capacity Market ("FCM"). ISO New England, Inc., operator of the region's bulk power system and wholesale electricity markets, will project the energy needs of the region three years in advance and then hold an annual auction to purchase power resources to satisfy the region's future needs.

In response to ISO-NE solicitation for proposals for the first forward capacity auction, ("FCA1"), CL&P and UI submitted new demand-response resource/energy efficiency projects that will decrease electricity use. Per ISO-NE requirements, detailed Project Qualification Packages that include Measurement and Verification Plans ("M&V") were submitted. The purpose of ISO-NE's required M&V activity is to verify that energy conservation measures promoted by the programs were actually installed; are still in place and functioning as intended; and to measure the reduction in electrical demand compared to some baseline pattern of use. The CL&P and UI Program Savings Documentation ("PSD"), serves as the underpinning of the demand reduction value calculations that will be submitted in the FCM.

CL&P and UI have worked together over the past several years to develop common assumptions regarding measured savings for all types of energy efficient measures. This manual is a compilation of those efforts. C&LM savings claims will be traceable through cross-references to this manual. The manual will be reviewed annually (or as needed) and updated to reflect changes in technology, baselines, measured savings, evaluation work, and impact factors.

The C&LM savings calculations in this manual represent typical measures and prescriptive calculations used for those measures. In some cases, projects are more comprehensive or prescriptive measure calculations are not appropriate. To accurately calculate the savings related to these types of projects, more detailed spreadsheets or computer simulation models (DOE-2, Trace, HAP) must be used. Third-party engineering consultants are contracted to run all simulations and create many of these more detailed spreadsheets; all are reviewed for reasonableness.

**Organization**

C&LM measures in this manual are grouped by primary sector and reflect how programs and measures are organized within C&LM. Commercial and Industrial (C&I) measures are also categorized as either "Lost Opportunity" or "Retrofit". The main sections of the manual are as follows:

- Introduction
- Section 2: C&I Lost Opportunity
- Section 3: C&I Retrofit
- Section 4: Small Business
- Section 5: Residential
- Section 6: Low Income
- Appendices

**Savings Calculations**

Savings results presented in this manual (both electric and non-electric) are assumed to be the savings that would be measured at the point of use. Electric savings (both kWh and kW) are assumed to be the savings that would occur at the customer's meter. Line losses are not included in the savings values presented here; their effects are captured within the screening model that the companies use to evaluate the benefits of conservation programs. In addition, the annual electric savings from measures has a specified load shape (i.e. the time of day and seasonal patterns at which savings occur). See Table 1.2 for load shapes for various end-use savings. The load shapes are used to properly assign the value of energy savings resulting from the implementation of C&LM measures to the corresponding time of day when those savings are realized.

The values for demand savings (for both winter and summer) in this manual are given based on two different definitions:

- A "Seasonal Peak" reduction is based on the average peak reduction for a measure during the ISO New England definition for a Seasonal Peak Demand Resource – when the real-time system hourly load is equal to or greater than 90% of the most recent "50/50" system peak load forecast for the applicable summer or winter season. The summer season is defined as non-holiday weekdays during the months of June, July and August; the winter season is defined as non-holiday weekdays during December and January. Typically, these peaks are weather driven and occur in the mid afternoon on hot summer weekdays, or for winter, the in early evening.

- An "On-Peak" reduction is based on the average peak savings from 1:00 p.m. to 5:00 p.m. on non-holiday weekdays during June, July and August. An on-peak winter resource is a resource that reduced peak from 5:00 p.m. to 7:00 p.m. during non-holiday weekdays in January and February.

For non-weather sensitive measures, the seasonal peak and on-peak reduction are similar or assumed to be the same. In situations where the peak savings for a measure differs based on the definition, both values are presented.

Peak demand savings (based on either definition) can be calculated either on a measure-by-measure basis; or, on a default basis, coincidence factors can be used to calculate demand savings based on the annual savings and load shape of the measure. Coincidence factors are multiplied by the connected load savings of the measure in order to obtain the peak demand savings. See Table 1.1 for a list of default coincidence factors that are used to calculate the peak demand savings.

In addition to electric benefits, some measures have non-electric benefits. Where appropriate, these benefits (or "impacts" since they can also be negative) are defined in this manual. Non-electric impacts may include quantifiable changes in fossil fuel consumption, water use, maintenance costs, productivity improvements, replacement costs, etc. Non-electric benefits are not included in the Electric System test; they are captured in the Total Resource Cost Test.

The savings for the measures defined in this manual are gross savings. Impact factors are applied to the gross savings to calculate the net (final) savings. Gross energy savings estimates (based on known technical parameters) represents the first step in calculating energy savings. Gross savings calculations are based on engineering algorithms or modeling that take into account technically important factors such as hours of use, differences in efficiency, differences in power consumption, etc.

When calculating the total impact of energy saving measures, there are also some other factors beyond the engineering parameters that need to be considered, such as the market effects of free-ridership, spillover or installation rate. The equation for net savings is as follows:

**Net Savings = Gross Savings x (1 + spillover – free-ridership) x Installation Rate**

In some cases, evaluation work may uncover differences between calculated savings and actual (metered) savings that may not be (completely) attributable to the impact factors above. These differences may arise when the savings calculations do not accurately capture the real savings attributable to a measure. In addition to the impact factors above, savings differences can happen for a variety of reasons such as non-standard usage patterns or operating conditions. In these cases, overall net-to-gross ratios (realization rates) may be used in addition to (or instead of) the aforementioned impact factors to bring the observed savings values more in line with the original savings calculations.

For instance, a billing analysis may show observed savings from a refrigerator removal program to be 60% of the gross (calculated) savings. In this case, the differences may be attributable to a combination of factors including refrigerators that are not being used, free-ridership, units being improperly used (e.g. the refrigerator door left open for long periods of time), and units that exhibit lower energy use because they are operating in cooler basement environments. In such a case, a 60% realization rate would be applied to the gross (calculated) energy savings to correct it.

Realization rates can be applied to specific measures or across programs depending on their source. Since commercial and industrial (C&I) programs typically offer a wide range of diverse measures, defining specific impact factors for Commercial and Industrial (C&I) programs can be difficult, and therefore program specific realization rates are usually limited to C&I programs. Table 1.3 contains a list of program specific realization rates. These rates have been updated from 2006 based on recent studies. Realization rates are no longer included in the description of each individual measure.

**Other Major Changes from 2007**

The following new C&I measures have been added:

2.2.6 Cooling – Gas-Driven Chiller
2.7.4 Custom
2.8.1 Cool Roof
3.1.2 Refrigerator LED
3.2.3 Cooling – Gas-Driven Chiller
4.1.2 SMB Refrigerator LED
4.3.4 SMB Cooler Night Covers
4.3.5 SMB Evaporator Fan Motor Replacement

The following new Residential measures have been added:

5.2.3 Ductless Heat Pump
5.4.7 New Tax Credit Home

In addition to the above measures, residential program administrators are reviewing literature and collecting data on the energy savings potential of whole house energy monitors. These monitors are designed to provide real-time feedback to customers to enable them to make informative decision regarding energy use. To date, despite some promising initial results from other utility pilots, the long-term energy savings potential of these devices remains unknown. As a result, this measure is not currently included in the PSD. The Companies will continue to keep a watchful eye on this technology and may update the PSD if deemed necessary and appropriate based on future findings.

## 1.2 GLOSSARY

The glossary provides definitions of the energy conservation terms used in this Program Savings Document. Note that some of these terms may have alternative or multiple definitions some of which may be outside the context of the manual. Only definitions pertaining to this manual are included in the glossary.

Baseline Efficiency: C&LM program savings are calculated from this efficiency value. It represents the value of efficiency of the equipment that would have been installed without any influence from the program. *Contrast compliance efficiency.*

Baseline Standard: The source or document that provides the Baseline Efficiency values, or a means to calculate these values. In many cases, the baseline efficiency is the minimum efficiency required by codes and standards, such as the Connecticut Energy Code.

Coincident Demand: Demand of a measure that occurs at the same time as some other peak (building peak, system peak, etc). In the context of this document, coincident demand is a measure of demand savings that is coincident with electric system peak demand.

Coincidence Factor: Coincidence factors represent the fraction of connected load expected to occur at the same time as a particular system peak period, on a diversified basis. Coincidence factors are normally expressed as a percent (of connected load). Also referred to as Diversity Factor.

Compliance Efficiency: This efficiency value must be achieved in order to qualify for a C&LM program incentive. *Contrast baseline efficiency.*

Compliance Standard: The source or document that provides the Compliance Efficiency values, or a means to calculate these values. In many cases the compliance efficiency is based on standards from recognized programs such as Energy Star.

Connected Load: This is the maximum power required by the equipment, usually expressed as kW.

Demand: The average electric power requirement (load) during a time period. Demand is measured in kW and the time period is usually one hour. If the time period is different than one hour, the time period is usually stated, such as “15-minute demand.” Demand can refer to an individual customer’s load or to the load of an entire electric system. *See Peak Demand.*

Demand Reduction, 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 discussion under Peak Demand Savings.*

Diversity Factor – See Coincidence Factor.

Electric System (benefit-cost ratio) Test: A ratio used to assess the effectiveness of energy efficiency efforts on the electric system. The electric system test is defined as the present value of the avoided electric system costs (including energy, capacity, transmission and distribution) divided by the program related costs of achieving the savings. The electric system test is the primary evaluation tool used to screen measures and programs in Connecticut. Energy efficiency efforts are cost-effective if the benefit-cost ratio is greater than 1.0.

End Use: Refers to a category of measures with similar load shapes. There are several different acceptable industry standards for defining end-use categories. For the purpose of this manual, end uses are cooling, heating, lighting, refrigeration, water heating, motors, process, and other.

Equivalent Full Load Hours (EFLH): This is the number of hours per year that the equipment would need to draw power at its connected load rating in order to consume its estimated annual kWh. It is calculated as annual kWh/connected kW. EFLH is the same as operating hours for technologies that are either on or off, such as light bulbs; EFLH is less than operating hours for technologies that operate at part load for some of the time, such as air conditioners and motors.

Evaluation Study: A study that is used to assess the true impacts of a program including but not limited to: energy and demand savings, non-electric benefits, market effects, program performance, or program cost-effectiveness.

Free-Rider: A program participant who would have installed or implemented an energy efficiency measure even in absence of program marketing or incentives.

Free-ridership: The fraction (usually expressed as a percent) of gross program savings that would have occurred even in the absence of a C&LM program.

Gross Savings: A saving estimate, calculated from objective technical factors. The gross savings do not include impact factors.

High Efficiency: The efficiency of the energy-saving equipment installed because of a conservation program. High efficiency equipment uses less energy than standard equipment.

Impact Evaluation: A study that assesses the energy, demand, nor non-electric benefits associated with energy efficiency measures or programs.

Impact Factor: A number (usually expressed as a percent) used to adjust the gross savings in order to reflect the savings observed by an impact study. Examples of impact factors include free-ridership, spillover and installation rate.

Installation Rate: The fraction of the recorded products that are installed. For example, some screw-in compact fluorescent lights are bought as spares, and will not be installed until another burns out.

Load Factor: The average fractional load at which the equipment runs. It is calculated as average load/connected load.

Load Shape: The time-of-use pattern of a customer's energy consumption or measure. Load shape can be defined as hourly and/or seasonally (winter/summer).

Lost Opportunity: Refers to the new installation of an enduring unit of equipment (in the case of new construction) or the replacement of an enduring unit of equipment at the end of its useful life. An enduring unit of equipment is one that would normally be maintained, not replaced, until the end of its life. *Contrast "retrofit"*

Market Effect: A change in the behavior of a market because of conservation efforts. "Market Effect savings" is the savings that results changes in market behaviors.

MBtu: Millions of Btu.

Measure: A product (a piece of equipment) or a process that is designed to provide energy or demand savings. Measure can also refer to a service or a practice that provides savings.

Measure Cost: For new construction or measures that are installed at their natural time of replacement (replace upon burn-out), measure cost is defined as the incremental cost of upgrading to high efficiency. For retrofit measures, measure cost is defined as the full cost of the measure. Measure cost refers to the true cost of the measure regardless of whether an incentive was paid for that measure.

Measure lifetimes: This is the average number of years (or hours) that a group of new high efficiency equipment will continue to produce energy savings or the average number of years that a service or practice will provide savings. Lifetimes are generally based on experience or studies.

Measure type: Refers to a category of similar measures. There are several different acceptable industry standards for defining end-use categories. For the purpose of this manual, end use categories are Lighting, HVAC, Motors, VFD (variable frequency drives), Refrigeration, Products & Services, Envelope, Renewable, and Other.

Net Savings: The final value of savings that is attributable to a program or measure. Net savings differs from "gross savings" because it includes adjustments from impact factors such as free-ridership or spillover. Net savings is sometimes referred to as "verified savings" or "final savings."

Net-to-gross: The ratio of net savings to the gross savings (for a measure or program). Net-to-gross is usually expressed as a percent.

Non-electric benefits: 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 (see spillover).

Operating Hours: The annual amount of time, in hours, that the equipment is expected to operate. *Contrast Equivalent Full Load Hours.*

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 his participation. Free-riders are a subset of this group.

Peak Demand: The highest demand.

Peak Demand Savings: The kW demand reduction that occurs in the peak hours. There is both a summer peak and a winter peak. Two peak periods are used:

- Seasonal peak, which consists of the highest demand hours in either summer or winter. Seasonal Peak hours are those in which the projected hourly load in the ISO next day forecast is equal to or greater than 90% of the ISO 50/50 peak forecast, for summer or winter. There are typically 25 to 75 such hours in a year.
- On peak, which consists of the entire summer or winter peak period. On-Peak Hours are each non-holiday weekday summer afternoon from 1 pm through 5 pm in June, July, and August; and winter evenings 5 pm through 7 pm in Dec. and Jan.

The peak demand savings is usually determined by multiplying the demand reduction attributed to the measure by the appropriate Seasonal or On-Peak coincidence factor. Coincidence factors for different measures for each peak are shown in Table 1.1.1.
The Seasonal Peak Demand savings are used in the C&LM programs. The On-Peak savings are used in ISO programs. *See also Coincidence Factor, Demand Savings.*

Peak Period: The annual time periods that experience the times of peak electrical demand. The Summer Peak Period consists of the non-holiday weekday hours from 1pm to 5pm in June through August. The Winter Peak Period consists of the non-holiday weekday hours from 5pm to 7pm in December and January.

Realization of Savings: The ratio of actual measure savings to gross measure savings (sometimes referred to as the “realization rate”). This ratio takes into account impact factors that can influence the actual savings of a program such as spillover, free-ridership, etc.

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. *Contrast “lost opportunity.”*

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.

SMB: Small Business

Spillover: Savings attributable to the program, but additional to the gross (tracked savings) of a program. Spillover include 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; or (b) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program.

Summer Demand Savings: Refers to the demand savings that occur during the summer peak period. *See discussion under peak demand savings.*

Summer System Peak: *See discussion under peak demand savings.*

Summer Peak Period: The non-holiday weekday hours from 1pm to 5pm in June through August.

Total Resource (Benefit/Cost) Test: A test used to assess the net benefit of energy efficiency resources to society. The total resource test is different from the electric system test in that the total resource benefit consists of the avoided costs of all conserved energy (electric *and* other fuels) plus other non-energy resource impacts that may have occurred because of efficiency efforts such as reduced maintenance or higher productivity. The cost for the total resource benefit consists of all program-related costs and any costs incurred by the customer related to the installation of measures.

Winter Demand Savings: Refers to average demand savings that occurs during the winter peak period. *See discussion under peak demand savings.*

Winter Peak Period: The non-holiday weekday hours from 5pm to 7pm in December and January.

# C&I LOST OPPORTUNITY

## 2.1.1 STANDARD LIGHTING

***Description of Measure***

Encourage and reward lighting power levels that are better than the standards.

***Method for Calculating Energy Savings***

KWh savings, $S = S_p + S_o + S_c$

$S_p$, kWh = (*Allowable LPD - Actual LPD*)*$H$*$A$
$S_o$, kWh = savings from use of occupancy sensors, if applicable,
$S_c$, kWh = savings from reduced cooling

*Allowable LPD,* in kW/ft$^2$, is the value of Watts per ft$^2$ from Ashrae 90.1-2001 for the facility type divided by 1000. (When using the space-by space method to calculate the LPD, an increase in the spaces' power allowances can be used, in accordance with Section 9.3.1.2.1 of Ashrae 90.1-2001.)

*Actual LPD,* in kW/ft$^2$, is calculated by dividing the total *Fixture Wattage* by the *Lighted Area, ft$^2$*

*Fixture Wattage* is determined from technical data, kW

*A = Lighted Area, ft$^2$.*, It is calculated for each project, either from architectural drawings or by physical measurement.

*H = Facility Lighting Hours,* per year, and is described in Table 2.0.0.

***$S_o$*** Calculation of kWh savings due to occupancy sensors

$S_o$ = Additional savings due to occupancy sensors

If the *Actual LPD* is less than or equal to the *Allowable LPD*, then $S_o$ will be calculated as follows; otherwise, $S_o = 0$.

$$S_O = \frac{0.3H}{1000}\sum_{n=1}^{N} O_n W_n$$

$H$ = Facility hours

$N$ = Number of different fixture types with occupancy sensors

$n$ = Fixture number

$O_n$ = Quantity of fixtures of type n that have occupancy sensors

$W_n$ = Input watts for fixture type n

Explanation of numerical constants:
- 0.3 is the generally accepted average energy reduction due to the use of occupancy sensors (see ref.)
- 1000 converts watts to kW

**$S_c$** Calculation of lighting kWh savings due to the reduced cooling required to remove excess heat produced by the lighting fixtures

$S_c$ = Additional savings due to the reduced cooling energy required to remove the energy from lighting

$$S_C = \frac{(S_P + S_O) \bullet F}{COP}$$

F = Fraction of annual kWh energy savings that must be removed by the cooling system

If the HVAC system includes an economizer,
Then F = 0.35
Otherwise, use the table below

| Building Area, A, Sq ft | F |
|---|---|
| < 2,000 | 0.48 |
| 2,000 – 20,000 | $0.48 + \frac{0.195(A - 2,000)}{18,000}$ |
| >20,000 | 0.675 |

COP = 2.4

The source of the equation for $S_c$ and the derivation of the values for F and COP is from “Calculating Lighting and HVAC Interactions,” Ashrae Journal 11-93 as used by KCPL.

***Method for Calculating Demand Savings***

$$KW = \frac{D \bullet (S_P + 0.34 S_o)}{H}(1 + G / COP)$$

D is the peak factor taken from Table 1.1.1.

G = 0.73, and is the estimated lighting energy heat to space, based on modeling results.

0.34 is a diversity factor used to estimate the demand effect due to occupancy sensors.

*Facility Lighting Hours* are defined in Appendix Table 2.0.0.

***Baseline Efficiencies from which savings are calculated***

The baseline allowable Lighting Power Densities are those shown in Ashrae 90.1-2001 Tables 9.3.1.1 and 9.3.1.2, as modified by Addenda (g) and (ag). These tables are reproduced in the Appendix as Tables 2.1.1.C and 2.1.1.D, respectively.

***Compliance Efficiency from which incentives are calculated***

0.05 W/ft$^2$ below the baseline LPD

***Operating Hours***

*Default Facility Lighting Hours* are taken from Table 2.0.0.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Space heating increase from reduced lighting load. Annual Fossil fuel Savings = -0.00079 MBTU's per annual kWh saved.

Based on August 22, 2003 Memorandum from Optimal energy, Inc..

***Non-Electric Benefits - Annual O&M Cost Adjustments***

O&M savings due to the reduction of lighting hours from installation of occupancy sensors. Annual O&M Savings = $0.014917 per annual kWh saved from the installation of occupancy sensors.

Based on August 22, 2003 Memorandum from Optimal energy, Inc..

***Notes & References***

Occupancy sensor savings reference:

1. D. Maniccia B. Von Neida, and A. Tweed.
An analysis of the energy and cost savings potential of occupancy sensors for commercial lighting systems
Illuminating Engineering Society of North America 2000 Annual Conference: Proceedings. IESNA: New York, NY. Pp. 433-459.

2. RLW Study "2005 Coincidence Factor Study With 1-5 Summer Peak Window", 7-20-06.

***Revision Number***

15

# 2.2.1 COOLING - CHILLERS

***Description of Measure***

This measure encourages the installation of efficient water-cooled and air-cooled water chilling packages (chillers). Chillers must use an environmentally friendly refrigerant in order to qualify for the program.

***Method for Calculating Energy Savings***

Energy savings are custom-calculated for each chiller installation based on the specific equipment, operational staging, operating profile, and load profile.

Equipment

Each chiller plant is characterized by its:

- Number of chillers,
- Sizes, in tons (the chillers may be of different sizes),
- Type, which may be:
  - Centrifugal,
    - R123 refrigerant,
    - R134a refrigerant
  - Water-cooled screw and scroll, or
  - Air-cooled
- Speed, constant or variable
- Auxiliary equipment
  - Chilled water pumps
  - Cooling tower pumps
  - Cooling tower fans
  - Other

Operational Staging

If more than one chiller is used, their operational relationship can be defined. When the load is high enough to permit two chillers to operate, they can be designated to operate together at the same loading, or, alternatively, either one can be operated at full output while the other follows the cooling load profile.

Operating Profile

The customer's cooling load profile, for each of 12 months, is characterized by:

- On-peak occupied hours the chiller is operated each week,
- Off-peak occupied hours the chiller is operated each week,
- On-peak un-occupied hours the chiller is operated each week,
- Off-peak un-occupied hours the chiller is operated each week.

Load Profile

The customer's load profile is estimated by determining the load at the peak outdoor conditions and the load at the minimum conditions. For systems with an air-side or water-side economizer, the minimum conditions are those just above the set point of the economizer. If the customer's load profile is not known, a default load profile will be developed; in this case it is also necessary to determine the value of any process loads.

Savings Calculation

With the above information, a calculation is made for each time period of the year based on the appropriate temperature bin data. The calculation is performed once for the chillers meeting the baseline efficiencies and again for the proposed chillers, and the difference determines the kWh and the kW savings for each period. These are summed to yield the total savings.

### ***Method for Calculating Demand Savings***

The demand savings calculation is described in the previous paragraph.

### ***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are those required by the Ct Building Code. These efficiencies are shown in Table 2.2.1.A in the Appendix.

### ***Compliance Efficiency from which incentives are calculated***

The chiller rating at ARI conditions must meet a minimum efficiency to qualify for an incentive. The minimum is set at an efficiency somewhat better than what Ashrae 90.1 requires. These minimum efficiency levels for the various sizes and types of chillers are shown in Table 2.2.1.A in the Appendix. The ARI conditions are shown in Table 2.2.1.B in the Appendix
The part-load efficiencies that are used to compute the savings are shown in Table 2.2.1.C. These values are not part of Ashrae 90.1-2001. They are based on reported part-load efficiencies of chillers.

### ***Operating Hours***

A single value for operating hours is not used. As described above, custom hourly calculations are made for each customer.

### ***Non-Electric Benefits - Annual Fossil Fuel Savings***

The realization of savings is based on program. Refer to table 7.1.3

### ***Revision Number***

09

## 2.2.2 COOLING - UNITARY AC & HEAT PUMPS

***Description of Measure***

This measure encourages the installation of efficient Direct-Expansion (DX) cooling systems for C&I customers.

***Method for Calculating Energy Savings***

**Cooling (A/C units and Air Source Heat Pumps)**

Annual kWh savings = $$Cap * \left( \frac{1}{EER_B} - \frac{1}{EER_I} \right) * \frac{1}{1000} * EFLH_C$$

$EFLH_c$ = Refer to Table 2.0.0

**Heating (Air source heat pumps only)**

Annual kWh savings = $$Cap * \frac{13{,}900}{12{,}000} * \left( \frac{1}{HSPF_B} - \frac{1}{HSPF_I} \right) * \frac{1}{1000} * EFLH_H$$

EFLHh = Refer to Table 2.0.0

Cap = Unit’s rated cooling capacity in Btu/h
$EER_i$ = Installed unit’s rated energy efficiency ratio
$EER_b$ = Baseline energy efficiency ratio from Table 2.3
(Note: $SEER_p$ and $SEER_b$ are used for units < 5.4 tons)
$HSPF_b$ = Baseline Heating seasonal performance factor, watt-hours per MBtu heat input, from ASHRAE 90.1-2004, Table 6.8.1B.
$HSPF_i$ = installed Heating seasonal performance factor
$EFLH_c$ = equivalent full load hours cooling
$EFLH_h$ = equivalent full load hours heating
1000 = converts Wh to kWh
Ratio 13900/12000 = ratio of heat produced in the heating mode divided by cooling produced in the cooling mode.

***Method for Calculating Demand Savings***

Summer kW savings = D* Cap * (1/($EER_b$)-1/($EER_i$)) /1000

Winter kW savings = 0,
Cooling only units have no winter demand savings since they do not operate during the winter.
Air source heat pumps have no winter demand savings because they use resistance back up at low outside air temperatures.

D = Peak Factor from Table 1.1.1

***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are shown in Table 2.3.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiencies are shown in Table 2.3.

***Operating Hours***

The operating hours are shown in Table 2.0.0.

***Incremental Cost***

Incremental Costs

| Size | | |
|---|---|---|
| Tons | MBtu/H | $/ton |
| Less than 5.4 | Less than 65 | $92 |
| 5.4 to under 11.25 | 65 to under 135 | $73 |
| 11.25 to under 20 | 135 to under 240 | $79 |
| 20 to under 30 | 240 to under 375 | $79 |
| 30 to under 63 | 375 to under 756 | $62 |
| 63 and over | 756 and over | $62 |

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

10

# 2.2.3 COOLING - WATER AND GROUND SOURCE HP

***Description of Measure***

The measure is to encourage efficiency upgrades of water-to-air heat pump units at the time of their replacement or new construction.

***Method for Calculating Energy Savings***

**Cooling**

Annual cooling kWh savings = Cap * (1/(EERb)-1/(EERi)) * $EFLH_c$/1000

$EFLH_c$ = refer to Table 2.0.0

**Heating**

Annual heating kWh savings = $$Cap * \frac{13{,}900}{12{,}000} * \left( \frac{1}{COP_B} - \frac{1}{COP_I} \right) * \frac{1}{3413} * EFLH_H$$

$EFLH_h$ = refer to Table 2.0.0

Cap = Unit's rated cooling capacity in Btu/h
$EER_i$ = Installed unit's rated energy efficiency ratio
$EER_b$ = Baseline energy efficiency ratio (see table below)
$COP_b$ = Baseline Heating Coefficient of performance
$COP_i$ = Installed Heating Coefficient of performance
$EFLH_c$ = equivalent full load hours cooling
$EFLH_h$ = equivalent full load hours heating
3413 = converts Btu/h to kW
Ratio 13900/12000 = ratio of heat produced in the heating mode divided by cooling produced in the cooling mode.

***Method for Calculating Demand Savings***

Summer kW savings = LF* Cap * (1/($EER_b$)-1/($EER_i$)) /1000

Winter kW savings = LF * (Cap / 12,000)*(1/$COP_b$ – 1/$COP_i$)*(13,900/3,413)

LF = Peak Load Factor from Table 1.1.1

***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are shown below. They are the same as required by the Ct Bldg code.

| | | |
|---|---|---|
| **Water Source Heat Pump** | | |
| **Btu/h** | **Baseline** | **Minimum Compliance** |
| < 17,000 | 11.2 EER, 4.2 COP | 14 EER, 4.2 COP |
| ≥ 17,000 | 12 EER, 4.2 COP | 14 EER, 4.2 COP |
| **Ground Water Heat Pump** | | |
| **Btu/h** | **Baseline** | **Minimum Compliance** |
| All | 16.2 EER, 3.6 COP | 18.0 EER, 3.6 COP |
| **Ground Loop Heat Pump** | | |
| **Btu/h** | **Baseline** | **Minimum Compliance** |
| All | 13.4 EER, 3.1 COP | 15.0 EER, 3.1 COP |

***Compliance Efficiency from which incentives are calculated***

The compliance efficiencies are shown in the above table.

***Operating Hours***

The operating hours are shown in Table 2.0.0.

***Incremental Cost***

Incremental cost = $81 per ton.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

07

## 2.2.4 COOLING - DUAL ENTHALPY CONTROLS

***Description of Measure***

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.

***Method for Calculating Energy Savings***

Annual cooling kWh savings = Tons * 276 kWh / Ton

Tons = Unit's rated cooling capacity in Tons

The 276 kWh / ton average savings is based on DOE-2 simulation results of modeling a broad cross section of building types and sizes.

***Method for Calculating Demand Savings***

Summer kW savings = 0

Demand savings are zero since the measure reduces energy when outside temperatures are low.

***Baseline Efficiencies from which savings are calculated***

HVAC operating with fixed dry-bulb economizer.

***Operating Hours***

The operating hours are not used in the calculation.

***Incremental Cost***

$250 per unit controlled

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

03

## 2.2.5 VENTILATION CO2 CONTROLS

***Description of Measure***

The measure is to upgrade CO2 control of outside air to an air handling system. The proposed systems monitor the CO2 in the spaces or return air and reduce the outside air when possible to save energy while meeting indoor air quality standards.

***Method for Calculating Energy Savings***

**Cooling**
The electrical savings are custom-calculated for all projects. Savings are based on hours of operation, return air dry bulb temperature, return air enthalpy, system total air flow, percent outside air, estimated average outside air reduction, and cooling efficiency. Savings are estimated based using a temperature BIN spreadsheet that calculates the difference in outside air enthalpy and return air enthalpy from the reduction in outside air.

***Method for Calculating Demand Savings***

Summer demand savings are calculated based on the top temperature BINs used in the spreadsheet.

***Baseline Efficiencies from which savings are calculated***

No ventilation control.

***Operating Hours***

Operating hours are site specific.

***Incremental Cost***

$750 to $1,500 per unit controlled.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The fossil fuel savings are custom-calculated for all projects. Savings are based on return air dry bulb temperature, return air enthalpy, system total air flow, percent outside air, estimated average outside air reduction, and boiler efficiency. Savings are estimated based using a temperature BIN spreadsheet that calculates the difference in outside air enthalpy and return air enthalpy from the reduction in outside air.

***Revision Number***

04

## 2.2.6 COOLING - GAS-DRIVEN CHILLER

***Description of Measure***

This measure encourages the installation of efficient water-cooled and air-cooled gas fired engine driven water chilling packages (chillers). Chillers must use an environmentally friendly refrigerant in order to qualify for the program.

***Method for Calculating Energy Savings***

Energy savings are custom-calculated for each chiller installation based on the specific equipment, operational staging, operating profile, and load profile.

Equipment

Each chiller plant is characterized by its:

- Number of chillers,
- Sizes, in tons (the chillers may be of different sizes),
- Type, which may be:
    - Centrifugal,
        - R123 refrigerant,
        - R134a refrigerant
    - Water-cooled screw and scroll, or
    - Air-cooled
    - Gas Engine Driven
- Speed, constant or variable
- Auxiliary equipment
    - Chilled water pumps
    - Cooling tower pumps
    - Cooling tower fans
    - Other

Operational Staging

If more than one chiller is used, their operational relationship can be defined. When the load is high enough to permit two chillers to operate, they can be designated to operate together at the same loading, peak shaving, or, alternatively, either one can be operated at full output while the other follows the cooling load profile.

Operating Profile

The customer’s cooling load profile, for each of 12 months, is characterized by:

- On-peak occupied hours the chiller is operated each week,
- Off-peak occupied hours the chiller is operated each week,
- On-peak un-occupied hours the chiller is operated each week,
- Off-peak un-occupied hours the chiller is operated each week.

Load Profile

The customer's load profile is estimated by determining the load at the peak outdoor conditions and the load at the minimum conditions. For systems with an air-side or water-side economizer, the minimum conditions are those just above the set point of the economizer. If the customer's load profile is not known, a default load profile will be developed; in this case it is also necessary to determine the value of any process loads.

Savings Calculation

With the above information, a calculation is made for each time period of the year based on the appropriate temperature bin data. The calculation is performed once for the chillers meeting the baseline efficiencies and again for the proposed chillers, and the difference determines the kWh and the kW savings for each period. These are summed to yield the total savings.

### ***Method for Calculating Demand Savings***

The demand savings calculation is described in the previous paragraph

### ***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are those required by the Ct Building Code for electric chillers. These efficiencies are shown in Table 2.2.1.A in the Appendix.

### ***Compliance Efficiency from which incentives are calculated***

The chiller rating at ARI conditions must meet a minimum efficiency to qualify for an incentive. Compliance efficiency is set to meet DPUC source BTU requirement.

| **Cooling System** | **Comfort Cooling (IPLV*)** | **Process Cooling (IPLV*)** |
|---|---|---|
| **Water-cooled** | | |
| < 150 tons | 1.6 COP | 2.0 COP |
| ≥ 150 & < 300 Tons | 1.7 COP | 2.2 COP |
| ≥ 300 Tons | 2.0 COP | 2.5 COP |
| **Air -cooled** | | |
| Any Size | 0.9 COP | 1.2 COP |
| * This requirement may be modified based on the amount of heat recovery. | | |

### ***Operating Hours***

A single value for operating hours is not used. As described above, custom hourly calculations are made for each customer.

### ***Incremental Cost***

Incremental cost will be based on site specific information.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The Non-electric fossil fuel benefit for this measure would be negative. The ‘savings’ would include any gas savings from the heat recovery minus the additional gas consumption from the engine. This would be estimated on a site specific basis.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

Additional annual O&M costs would be added maintenance costs of the engine. These would be estimated on a site specific basis.

***Revision Number***

02

## 2.3.1 C&I LO MOTORS

***Description of Measure***

The measure is to upgrade a motor at the time of replacement or new construction.

***Method for Calculating Energy Savings***

Annual kWh savings = Hp (0.746 kW/hp) (D) (1/EFFb -1/EFFi) (HRS)

Hp = motor's rated horsepower
D = Peak Factor from Table 1.1.1
EFFb = Baseline efficiency (see table below)
EFFi = Installed motor efficiency (see table below)
HRS = Annual Hours of operation

***Method for Calculating Demand Savings***

kW savings = Hp (0.746 kW/hp) (D) (1/EFFb -1/EFFi)

***Baseline Efficiencies from which savings are calculated***

| **Baseline motor Efficiencies (EPACT 1992)** | | | | | | |
|---|---|---|---|---|---|---|
| | **Open Drip Proof** | | | **Totally Enclosed Fan Cooled** | | |
| **HP** | **1200 rpm** | **1800 rpm** | **3600 rpm** | **1200 rpm** | **1800 rpm** | **3600 rpm** |
| 1 | 80.0 | 82.5 | 77.5 | 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 |

***Compliance Efficiency from which incentives are calculated***

| **Minimum Motor Compliance Efficiencies** | | | | | | |
|---|---|---|---|---|---|---|
| | **Open Drip Proof** | | | **Totally Enclosed Fan Cooled** | | |
| **HP** | **1200 rpm** | **1800 rpm** | **3600 rpm** | **1200 rpm** | **1800 rpm** | **3600 rpm** |
| 1 | 82.5 | 85.5 | 77.0 | 82.5 | 85.5 | 77.0 |
| 1.5 | 86.5 | 86.5 | 84.0 | 87.5 | 86.5 | 84.0 |
| 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 | 91.0 | 88.5 | 91.0 | 91.7 | 89.5 |
| 10 | 91.7 | 91.7 | 89.5 | 91.0 | 91.7 | 90.2 |
| 15 | 97.7 | 93.0 | 90.2 | 91.7 | 92.4 | 91.0 |
| 20 | 92.4 | 93.0 | 91.0 | 91.7 | 93.0 | 91.0 |
| 25 | 93.0 | 93.6 | 91.7 | 93.0 | 93.6 | 91.7 |
| 30 | 93.6 | 94.1 | 91.7 | 93.0 | 93.6 | 91.7 |
| 40 | 94.1 | 94.1 | 92.4 | 94.1 | 94.1 | 92.4 |
| 50 | 94.1 | 94.5 | 93.0 | 94.1 | 94.5 | 93.0 |
| 60 | 94.5 | 95.0 | 93.6 | 94.5 | 95.0 | 93.6 |
| 75 | 94.5 | 95.0 | 93.6 | 94.5 | 95.4 | 93.6 |
| 100 | 95.0 | 95.4 | 93.6 | 95.0 | 95.4 | 94.1 |
| 125 | 95.0 | 95.4 | 94.1 | 95.0 | 95.4 | 95.0 |
| 150 | 95.4 | 95.8 | 94.1 | 95.8 | 95.8 | 95.0 |
| 200 | 95.4 | 95.8 | 95.0 | 95.8 | 96.2 | 95.4 |

***Operating Hours***

Default Facility Hours are taken from Table 2.0.0

***Incremental Cost***

| **Minimum Motor Incremental Costs** | | | | | | |
|---|---|---|---|---|---|---|
| | **Open Drip Proof** | | | **Totally Enclosed Fan Cooled** | | |
| **HP** | **1200 rpm** | **1800 rpm** | **3600 rpm** | **1200 rpm** | **1800 rpm** | **3600 rpm** |
| 1 | $45 | $45 | $45 | $50 | $50 | $50 |
| 1.5 | $45 | $45 | $45 | $50 | $50 | $50 |
| 2 | $54 | $54 | $54 | $60 | $60 | $60 |
| 3 | $54 | $54 | $54 | $60 | $60 | $60 |
| 5 | $54 | $54 | $54 | $60 | $60 | $60 |
| 7.5 | $81 | $81 | $81 | $90 | $90 | $90 |
| 10 | $90 | $90 | $90 | $100 | $100 | $100 |
| 15 | $104 | $104 | $104 | $115 | $115 | $115 |
| 20 | $113 | $113 | $113 | $125 | $125 | $125 |
| 25 | $117 | $117 | $117 | $130 | $130 | $130 |
| 30 | $135 | $135 | $135 | $150 | $150 | $150 |
| 40 | $162 | $162 | $162 | $180 | $180 | $180 |
| 50 | $198 | $198 | $198 | $220 | $220 | $220 |
| 60 | $234 | $234 | $234 | $260 | $260 | $260 |
| 75 | $270 | $270 | $270 | $300 | $300 | $300 |
| 100 | $360 | $360 | $360 | $400 | $400 | $400 |
| 125 | $540 | $540 | $540 | $600 | $600 | $600 |
| 150 | $630 | $630 | $630 | $700 | $700 | $700 |
| 200 | $630 | $630 | $630 | $700 | $700 | $700 |

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

03

## 2.4.1 HVAC VFD

***Description of Measure***

Add variable frequency (VFD) control of a fan or pump system in a HVAC application. The fan (pump) speed will be controlled to maintain the desired system pressure. The application must have a load that varies and proper controls (Two –way valves, VAV boxes) must be installed.

***Method for Calculating Energy Savings***

Annual kWh savings = (BHP /EFFi) (Hrs) ( kWhSF)

***Method for Calculating Demand Savings***

Demand Savings = (BHP /EFFi)(kWSF)

BHP = System brake horsepower
EFFi = Installed motor efficiency
HRS = Annual Hours of operation
kWhSF = annual kWh savings factor based on typical load profile for application
kWSF = kW savings factor based on typical peak load from load of application
AF/BI = Air foil / backward incline
AF/BI IGV = AF/BI Inlet guide vanes
FC = Forward curved
FC IGV = FC Inlet guide vanes
CHWP = Chilled Water Pump
HWP = Hot Water Pump

| **HVAC Fan VFD Savings Factors** | | | |
|---|---|---|---|
| **Baseline** | **kWhSF** | **Summer kWSF** | **Winter kWSF** |
| Constant Volume | 0.53450577 | 0.34753664 | 0.65064177 |
| AF/BI | 0.35407485 | 0.26035565 | 0.40781240 |
| AF/BI IGV | 0.22666226 | 0.12954823 | 0.29144821 |
| FC | 0.17889831 | 0.13552275 | 0.18745625 |
| FC IGV | 0.09210027 | 0.02938371 | 0.13692166 |

| **HVAC Pump VFD Savings Factors** | | | |
|---|---|---|---|
| **System** | **kWhSF** | **Summer kWSF** | **Winter kWSF** |
| CHWP | 0.43277633 | 0.299056883 | 0.0 |
| HWP | 0.48198088 | 0.0 | 0.207967853 |

The above constants were derived using a temperature BIN spreadsheet and typical heating, cooling and fan load profiles.

***Baseline Efficiencies from which savings are calculated***

Based on the type of system. (See above table)

***Operating Hours***

Default Facility Hours are taken from Table 2.0.0

***Incremental Cost***

| HVAC VFD incremental Costs | | |
|---|---|---|
| HP | Fan | Pump |
| 5 | $920 | $1,710 |
| 7.5 | $1,310 | $2,100 |
| 10 | $1,320 | $2,150 |
| 15 | $1,370 | $2,300 |
| 20 | $1,760 | $2,730 |
| 25 | $2,270 | $3,290 |
| 30 | $2,420 | $3,670 |
| 40 | $2,480 | $3,770 |
| 50 | $3,390 | $4,580 |
| 60 | $5,130 | $6,680 |
| 75 | $6,190 | $7,730 |
| 100 | $7,670 | $9,290 |

***Total Cost***

Total cost to add VFD to existing system is approximately twice the incremental cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

06

## 2.5.1 ICE-CUBE MAKERS

***Description of Measure***

This measure encourages the installation of efficient commercial ice-cube machines. It is based on the Consortium for Energy Efficiency's (CEE) guidelines, which is based, in turn, on FEMP guidelines.

***Method for Calculating Energy Savings***

For each ice-making machine proposed for this measure, the ice harvest rate, the energy consumption rate and the type of machine are needed.

$$S = \frac{E - A}{100} R \bullet 365$$

S = Savings, kWh per year
E = Baseline energy use rate, kWh per 100 lb of ice produced.
A = Actual energy use rate, kWh per 100 lb of ice produced.
100 = Conversion to kWh per lb.
R = Ice harvest rate, lb per day.
365 = Conversion to kWh per year.

***Method for Calculating Demand Savings***

$$kW = \frac{E - A}{100} \bullet \frac{R}{24}$$

kW = Demand savings, kw
E = Baseline energy use rate, kWh per 100 lb of ice produced.
A = Actual energy use rate, kWh per 100 lb of ice produced.
100 = Conversion to kWh per lb.
R = Ice harvest rate, lb per day.
24 = Conversion to kw.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is taken from the CEE program. These values are derived from FEMP.

| 1/11/2005 | | Baseline Energy Rate , E, kwh/100lb | | |
|---|---|---|---|---|
| Type | Type Description | Up To R, lb/day | E= | Otherwise, E= |
| SC-A | Self-Contained -Air-Cooled | 125 | 26.4-0.11R | 12.4 |
| SC-W | Self-Contained - Water-Cooled | 300 | 12.43-.0114R | 9 |
| IMH-A | Ice-Making Head - Air-Cooled | 450 | 15.42 -0.0176 R | 7.5 |
| IMH-W | Ice-Making Head - Water-Cooled | 470 | 12.04-0.0122R | 6.3 |
| RCU-A | Remote Condensing Unit -Air-Cooled | 910 | 10.6-0.0039R | 7 |

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is Tier 1 as defined by CEE.

***Operating Hours***

Operating hours are not used in the savings calculation.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

04

## 2.5.2 SOLID-DOOR REFRIGERATORS AND FREEZERS

***Description of Measure***

This measure encourages the installation of efficient commercial refrigerators and freezers with solid-doors. It is based on the Consortium for Energy Efficiency's (CEE) guidelines, which is based, in turn, on FEMP guidelines.

***Method for Calculating Energy Savings***

For each commercial refrigerator or freezer with solid-doors proposed for this measure, the internal volume, the energy consumption rate and the type of machine are needed.

S = E – A(365)

S = Savings, kWh per year
E = Baseline energy use rate, kWh per year.
A = Actual energy use rate, kWh per day.

The value of A is provided by CEE for each make, size, and type of equipment.

***Method for Calculating Demand Savings***

$$kW = \frac{S}{8760}$$

S = Savings, kWh per year
8760 = No. of hours per year

***Baseline Efficiencies from which savings are calculated***

The Baseline Energy Use Rate, kWh/yr, for Solid-Door refrigerators is:
E = Internal Volume times 45.624 + 1007

The Baseline Energy Use Rate, kWh/yr, for Solid-Door freezers is:
E = Internal Volume times 145.25 + 833

These equations are derived from CEE data, and will be updated as appropriate.

***Compliance Efficiency from which incentives are calculated***

The Tier 1 and 2 qualifying values are the same as proposed by CEE.

Commercial Solid Door Refrigerators and Freezers High Efficiency Specification

| Equipment Type | | Maximum energy use per day (kWh/day) |
|---|---|---|
| Refrigerator | Tier 1 | .10V + 2.04 |
| | Tier 2 | .06V + 1.22 |
| Freezer | Tier 1 | .40V + 1.38 |
| | Tier 2 | .28V + 0.97 |

V = Interior Volume in cubic feet determined by ANSI/AHAM HRF1-1979
Test Method ANSI / ASHRAE 117 – 1992 @ 38$^o$ F +/- 2$^o$ F
2004 Consortium for Energy Efficiency, Inc.

Notes
1. Specifications were developed by Consortium for Energy Efficiency, Inc., 617-589-3949, http://www.cee1.org
2. Specifications were reproduced with permission from CEE
3. Specifications represent voluntary performance levels by Equipment Manufacturers
4. Products qualified using ASHRAE standard 117-2002 @ 38$^o$F+/- 2$^o$F

***Operating Hours***

This equipment is assumed to operate continuously.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

Consortium for Energy Efficiency, Inc., 617-589-3949, http://www.cee1.org

***Revision Number***

04

## 2.5.3 GLASS-DOOR REFRIGERATORS

***Description of Measure***

This measure encourages the installation of efficient commercial refrigerators with glass doors. It is based on the Consortium for Energy Efficiency's (CEE) guidelines, which is based, in turn, on FEMP guidelines.

***Method for Calculating Energy Savings***

For each refrigerator proposed for this measure, the annual energy savings is supplied directly by CEE based on the internal volume.

For Refrigerators meeting Tier 1 standards,
S = 19V+521

For Refrigerators meeting Tier 2 standards,
S = 50.6V+112.3

S = Savings, kWh per year
V = Internal volume, cu. ft.

***Method for Calculating Demand Savings***

$$kW = \frac{S}{8760}$$

S = Savings, kWh per year
8760 = No. of hours per year

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is assumed by CEE to be the least-efficient equipment on the market, and is included in the equation for energy savings.

***Compliance Efficiency from which incentives are calculated***

Commercial Glass Door, Reach-In High Efficiency Specification

| | Maximum energy use per day (kWh/day) |
|---|---|
| Tier 1 | .12V + 3.34 |
| Tier 2 | .086V + 2.39 |

V = Interior Volume in cubic feet determined by ANSI/AHAM HRF1-1979
Test Method ANSI / ASHRAE 117 – 1992 @ 38$^{o}$ F +/- 2$^{o}$ F
2004 CEE

***Operating Hours***

This equipment is assumed to operate continuously.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

Consortium for Energy Efficiency, Inc., 617-589-3949, http://www.cee1.org

***Revision Number***

05

## 2.5.4 VENDING MACHINE OCCUPANCY CONTROLS

***Description of Measure***

Installation of vending machine occupancy sensors to limit energy consumption in periods of no usage.

***Method for Calculating Energy Savings***

Annual savings = 1,600 kWh per vending machine

Savings are based on a 2001 study done by the Nicholas Group, P.C.

***Method for Calculating Demand Savings***

Demand savings = 0

***Baseline Efficiencies from which savings are calculated***

Existing vending machine operating without the occupancy sensor control.

***Incremental Cost***

$75 per unit

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

05

## 2.6.1 COMPUTER POWER SUPPLY

***Description of Measure***

Computers with a more efficient power supply.

***Method for Calculating Energy Savings***

Savings are based on estimates of a typical computer's usage. Study provided by the Ecos Group.
Annual kWh savings = 85 kWh/computer

***Method for Calculating Demand Savings***

kW = 0.016 kW / computer

***Operating Hours***

Not used in calculation.

***Incremental Cost***

$5.00

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

02

# 2.7.1 LEAN MANUFACTURING

***Description of Measure***

Incorporating PRIME (LEAN) in the manufacturing process allows a company to produce more in the same given time period. The savings are based on estimating the production increase with and without PRIME. Savings are based on two concepts: 1) Producing the more products in the same time period saves on the non- manufacturing consumption (mostly lighting). 2) Producing more products over the same time period reduces losses in the manufacturing equipment consumption (Less idle time, motors loaded more are more efficient.

Note: The PRIME process also reduces waste. Since this is very site dependent it typically is not considered in this calculation.

***Method for Calculating Energy Savings***

Annual Kwh savings = (EACWoP – EACWP)

Baseline:
EACWoP: Estimated annual consumption without PRIME at increased production levels

EACWoP = Production kWh + Office kWh + Other kWh
Production kWh = 0.75 (PPA) (AkWh) ( PAP/EP)
Office kWh = 0.05 (PPA) (AkWh)
Other kWh = 0.20 (PPA) (AkWh) (PAP/EP)

EACWP = Estimated annual consumption with PRIME at increased production levels

EACWP = Production kWh + Office kWh + Other kWh
Production kWh = 0.75 (PPA) (AkWh) (1+(1/EP)(0.94)(PAP-EP))
Office kWh = 0.05 (PPA) (AkWh)
Other kWh = 0.20 (PPA) (AkWh)

PPA = Percentage of facility's total products affected By PRIME
AkWh = Existing annual kWh
PAP = number of products produced after PRIME
EP = existing number of products produced

***Method for Calculating Demand Savings***

kW Savings = 0

***Baseline Efficiencies from which savings are calculated***

Baseline is calculated existing production methodology with increased production levels.

***Operating Hours***

Not used in calculation.

***Incremental Cost***

None

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

The customer's cost savings from the increase in productivity and reduction in scrap would be quantified on a case by case basis.

***Notes & References***

Savings calculation is preliminary for 2007. May be modified based on ERS study. Measure life will be 5 years.

***Revision Number***

05

## 2.7.4 CUSTOM

***Description of Measure***

This measure is used for C&I Lost Opportunity installations not covered by another specific measure.

***Method for Calculating Energy Savings***

Energy savings are calculated on a custom basis for each customer's specific situation. The savings are the difference in energy usage between the baseline and after conditions.

***Method for Calculating Demand Savings***

Measures may be lumped into two significantly different categories:
1.) Temperature-dependent (HVAC measures that vary with ambient temperature),
2.) Measures that are not temperature-dependent (process, lighting, time control).

Temperature-dependent methodologies:

The methodology used to determine the demand savings for temperature-dependent measures will depend on the type of analysis used to estimate the savings. Savings from temperature-dependent measures are typically determined by either full load hour analysis, bin temperature analysis, or a detailed computer simulation. The following will be the procedure used to estimate the demand savings for these measures:

When annual savings are calculated using a full load hour analysis, an appropriately derived (for measure and peak time period [On-Peak, Seasonal]) coincidence factor will be used for a measure that has a connected load that can be determined from rated or nameplate data. Demand savings will be the connected load kW savings times the appropriate coincidence factor.

When using a temperature bin analysis to calculate the energy savings, the demand (kW) savings are averaged over the appropriate temperature bins (On-Peak, Seasonal).

When a computer simulation is used to calculate savings, the demand savings will be averaged over the appropriated peak time period (On-Peak, Seasonal).

Non-Temperature-dependent measures:

Demand savings for measures that are not temperature-dependent will be determined by either the coincidence factors from Table 1.1.1 or the average estimated savings over the appropriate peak time periods (On-Peak, Seasonal). For example, for a process VFD measure, the savings will depend on cycling of the load. This cycling may occur many times during an hour. If the process is operating throughout the Seasonal summer period, the average demand savings will be:

(annual kWh savings)/(annual equivalent full load hours of operation).

If the process is operated only a portion of that time period the demand savings will be prorated based on that portion.

***Baseline Efficiencies from which savings are calculated***

Baseline efficiencies are based on code or common practice whichever is more efficient.

***Compliance Efficiency from which incentives are calculated***

There is no set compliance efficiency.

***Operating Hours***

The operating hours are determined on a case-by-case basis.

***Incremental Cost***

Incremental cost will be done on a case-by-case basis.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits are analyzed on a case-by-case basis.

***Revision Number***

02

## 2.8.1 COOL ROOF

***Description of Measure***

The measure is to upgrade a roof's reflectance at the time of replacement or new construction.

***Method for Calculating Energy Savings***

A number of HVAC system configurations were simulated using a DOE-2 building simulation model. Results of these simulations were reviewed and (based on relative energy savings) were separated into two categories depending on the location of the cooling equipment's condenser. The savings results were based on roof square footage over electrically air conditioned space. Based on those results the following equations are used to estimate annual electric savings.

When air conditioning equipment is located on the roof (rooftop units, split systems, air cooled chillers)(does not include cooling towers)

Annual kWh savings = (ASF) (0.29872 kWh/SF)
ASF = Square footage of upgraded roof that is over electrically air conditioned spaces

When air conditioning equipment is not located on the roof (split systems, air cooled chillers, water cooled chillers)
Annual kWh savings = (ASF) (0.08145 kWh/SF)

***Method for Calculating Demand Savings***

When air conditioning equipment is located on the roof (rooftop units, split systems, air cooled chillers)(does not include cooling towers)

Summer Peak kW savings = (ASF) (0.00045 kW/SF)

When air conditioning equipment is not located on the roof (split systems, air cooled chillers, water cooled chillers)
Summer Peak kW savings = (ASF) (0.00019 kW/SF)

***Baseline Efficiencies from which savings are calculated***

Based on the Energy Cost Budget Method in ASHRAE 90.1-2001 that requires that roofs be modeled with a reflectance of 0.3.

***Compliance Efficiency from which incentives are calculated***

The new roof must provide a minimum reflectance of 0.70 and a minimum emittance of 0.75 as certified and labeled by the Cool Roof Rating Council (CRRC).

***Operating Hours***

N/A

***Incremental Cost***

$0.20 per square foot

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Based on the DOE-2 model the average annual increase in fossil fuel usage was determined to be 0.0017 MBTU/SF.

***Revision Number***

05

# C&I RETROFIT

## 3.1.1 STANDARD LIGHTING

***Description of Measure***

This measure provides an incentive to replace inefficient lighting with efficient lighting.

***Method for Calculating Energy Savings***

KWh savings, $S = S_R + S_c$

$S_R$, kWh = savings from retrofit of reduced-wattage lamps,
$S_c$, kWh = savings from reduced cooling

$S_R = (kW_B - kW_A)\ H$

$S_R$ = Energy savings, kWh/year
$kW_B$ = The total power usage of the lighting fixtures that are being replaced, kW.
$kW_A$ = The total power usage of the new lighting fixtures that are being installed, kW.
H = The number of hours during which the lighting is used at the facility, hours/year.

**$S_c$** Calculation of lighting kWh savings due to the reduced cooling required to remove excess heat produced by the lighting fixtures. This is a simplified version of the method used in C&I Section 2.1.1

$S_c$ = Additional savings due to the reduced cooling energy required to remove the energy from lighting, kWh per year.

$$S_C = \frac{(S_R) \bullet F}{COP}$$

F = Fraction of annual kWh energy savings that must be removed by the cooling system, as determined from the table below:

| Building Area, A, Sq ft | F |
|---|---|
| < 2,000 | 0.48 |
| 2,000 – 20,000 | $0.48 + \frac{0.195(A - 2,000)}{18,000}$ |
| >20,000 | 0.675 |

COP = 2.4

The source of the equation for $S_c$ and the derivation of the values for F and COP is from "Calculating Lighting and HVAC Interactions," Ashrae Journal 11-93 as used by KCPL.

***Method for Calculating Demand Savings***

$$KW = \frac{D \bullet \left(S_P + 0.34 S_o\right)}{H}(1 + G / COP)$$

D is the peak factor taken from Table 1.1.1.

G = 0.73, and is the estimated lighting energy heat to space, based on modeling results.

0.34 is a diversity factor used to estimate the demand effect due to occupancy sensors.

H = the number of hours used in the energy savings calculation.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Compliance Efficiency from which incentives are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis, or the default facility hours are used from Table 2.0.0.

***Total Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Space heating increase from reduced lighting load. Annual Fossil fuel Savings = -0.00079 MBTU's per annual kWh saved.

Based on August 22, 2003 Memorandum from Optimal energy, Inc..

***Non-Electric Benefits - Annual O&M Cost Adjustments***

O&M savings are due to the installation of new equipment. O&M Savings = $0.003667 per annual kWh saved.

Based on August 22, 2003 Memorandum from Optimal energy, Inc..

***Revision Number***

06

## 3.1.2 REFRIGERATOR LED

***Description of Measure***

This measure calculates the savings when older fluorescent lighting in commercial display refrigerators, coolers and freezers is replaced with LED systems intended for this application.

***Method for Calculating Energy Savings***

S = KW* H

S = Energy savings, kWh/year
KW = the total kW savings of the refrigeration package, as defined in the next section.
H = The number of hours during which the lighting is used at the facility, hours/year.

***Method for Calculating Demand Savings***

KW = ($kW_B$ –$kW_A$)* Compressor factor

KW = the total kW savings of the refrigeration package, including the kW reduction due to the fixture replacement, and the reduced operation of the compressor due to not having to remove the excess lighting energy.
$kW_B$ = The total power usage of the lighting fixtures that are being replaced, kW.
$kW_A$ = The total power usage of the new lighting fixtures that are being installed, kW.
Compressor factor = 1.51 for coolers and 1.65 for freezers. The factors are based on effective refrigeration compressor EER values of 6.7 and 5.25 Btu/Wh, respectively.

Note: All of the kW savings associated with display refrigeration occur at the peak times because the lights are always on during the peak.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Compliance Efficiency from which incentives are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis, or the default facility hours are used from Table 2.0.0.

***Total Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

01

## 3.2.1 COOLING - ELECTRIC CHILLER

***Description of Measure***

This measure encourages the installation of efficient water-cooled and air-cooled water chilling packages (chillers) as replacements for less-efficient chillers. Chillers must use an environmentally friendly refrigerant in order to qualify for the program.

***Method for Calculating Energy Savings***

The energy consumption is custom-calculated for each chiller installation based on the specific equipment, operational staging, operating profile, and load profile.

These calculations are performed for both the old chiller plant and the new chiller plant. The difference in energy consumption between the two plants is the energy savings.

Equipment

Each chiller plant is characterized by its:

- Number of chillers,
- Sizes, in tons (the chillers may be of different sizes),
- Type, which may be:
    - Centrifugal,
        - R123 refrigerant,
        - R134a refrigerant
    - Water-cooled screw and scroll, or
    - Air-cooled
- Speed, constant or variable
- Auxiliary equipment
    - Chilled water pumps
    - Cooling tower pumps
    - Cooling tower fans
    - Other

Operational Staging

If more than one chiller is used, their operational relationship can be defined. When the load is high enough to permit two chillers to operate, they can be designated to operate together at the same loading, or, alternatively, either one can be operated at full output and the other can follow the cooling load profile.

Operating Profile

The customer's cooling load profile, for each of 12 months, is characterized by the:

- On-peak occupied hours the chiller is operated each week,
- Off-peak occupied hours the chiller is operated each week,
- On-peak un-occupied hours the chiller is operated each week,
- Off-peak un-occupied hours the chiller is operated each week.

Load Profile

The customer's load profile is estimated by determining the load at the peak outdoor conditions and the load at the minimum conditions. For systems with an air-side or water-side economizer, the minimum conditions are those just above the set point of the economizer. If the customer's load profile is not known, a default load profile will be developed; in this case it is also necessary to determine the value of any process loads.

Savings Calculation

With the above information, a calculation is made for each time period of the year based on the appropriate temperature bin data. The calculation is performed once for the old chillers and again for the proposed chillers, and the difference determines the kWh and the kW savings for each period. These are summed to yield the annual total savings for each year of the remaining life of the old chiller.

### ***Method for Calculating Demand Savings***

The demand savings calculation is described in the previous paragraph.

### ***Baseline Efficiencies from which savings are calculated***

Savings are calculated using the old chiller as the baseline.

### ***Compliance Efficiency from which incentives are calculated***

The proposed replacement chiller rating at ARI conditions must meet a minimum efficiency to qualify for an incentive. The minimum is set at an efficiency somewhat better than what Ashrae 90.1 requires. These minimum efficiency levels for the various sizes and types of chillers are shown in Table 2.2.1.A in the Appendix. The ARI conditions are shown in Table 2.2.1.B in the Appendix.

### ***Operating Hours***

A single value for operating hours is not used. As described above, custom hourly calculations are made for each customer.

### ***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

### ***Revision Number***

05

## 3.2.2 COOLING - HVAC

***Description of Measure***

This measure provides an incentive to replace inefficient cooling systems with systems that exceed the current efficiency standards.

***Method for Calculating Energy Savings***

$$S = \left( \frac{12}{[S/EER]_B} - \frac{12}{[S/EER]_P} \right) \bullet H \bullet T$$

S = Annual savings, kWh
$S/EER_B$ = Efficiency of the equipment being replaced, expressed as SEER or EER
$S/EER_P$ = Proposed efficiency expressed as SEER or EER. This value must be at least the value shown in Table 2.3.
H = Equivalent full load hours (EFLH) per year for the facility. The default hours are shown in Table 2.0.0.
T = Size, in tons
12 = Factor to convert from EER to kW/ton

***Method for Calculating Demand Savings***

$$KW = \left( \frac{12}{[S/EER]_B} - \frac{12}{[S/EER]_P} \right) \bullet T \bullet D$$

KW = Peak demand savings, kW
$S/EER_B$ = Before efficiency expressed as SEER or EER
$S/EER_P$ = Proposed efficiency expressed as SEER or EER
T = Size, in tons
12 = Factor to convert from EER to kW/ton
D = Peak Factor from Table 1.1.1

***Baseline Efficiencies from which savings are calculated***

There are no set baseline efficiencies. The energy savings are calculated as the difference between what is replaced and what is installed.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiencies are shown in Table 2.3. The compliance efficiencies are the same as in the Cool Choice program for the size range covered by Cool Choice (up to 30 tons).

***Operating Hours***

The default value for equivalent full load hours (EFLH) per year for the facility is taken from Table 2.0.0.

***Incremental Cost***

The incremental cost is the difference in cost between the replacement unit and the cost of a unit that meets only the minimum required efficiency. Values for the minimum required efficiency are shown in the table in Sec 2.2.2.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

08

# 3.2.3 COOLING - GAS-DRIVEN CHILLER

***Description of Measure***

This measure encourages the installation of efficient water-cooled and air-cooled gas fired engine driven water chilling packages (chillers) as replacements for less-efficient chillers. Chillers must use an environmentally friendly refrigerant in order to qualify for the program.

***Method for Calculating Energy Savings***

The energy consumption is custom-calculated for each chiller installation based on the specific equipment, operational staging, operating profile, and load profile.

These calculations are performed for both the old chiller plant and the new chiller plant. The difference in energy consumption between the two plants is the energy savings.

Equipment

Each chiller plant is characterized by its:

- Number of chillers,
- Sizes, in tons (the chillers may be of different sizes),
- Type, which may be:
  - Centrifugal,
    - R123 refrigerant,
    - R134a refrigerant
  - Water-cooled screw and scroll, or
  - Air-cooled
  - Gas engine driven
- Speed, constant or variable
- Auxiliary equipment
  - Chilled water pumps
  - Cooling tower pumps
  - Cooling tower fans
  - Other

Operational Staging

If more than one chiller is used, their operational relationship can be defined. When the load is high enough to permit two chillers to operate, they can be designated to operate together at the same loading, peak shaving, or, alternatively, either one can be operated at full output and the other can follow the cooling load profile.

Operating Profile

The customer's cooling load profile, for each of 12 months, is characterized by the:

- On-peak occupied hours the chiller is operated each week,
- Off-peak occupied hours the chiller is operated each week,
- On-peak un-occupied hours the chiller is operated each week,
- Off-peak un-occupied hours the chiller is operated each week.

Load Profile

The customer's load profile is estimated by determining the load at the peak outdoor conditions and the load at the minimum conditions. For systems with an air-side or water-side economizer, the minimum conditions are those just above the set point of the economizer. If the customer's load profile is not known, a default load profile will be developed; in this case it is also necessary to determine the value of any process loads.

Savings Calculation

With the above information, a calculation is made for each time period of the year based on the appropriate temperature bin data. The calculation is performed once for the old chillers and again for the proposed chillers, and the difference determines the kWh and the kW savings for each period. These are summed to yield the annual total savings for each year of the remaining life of the old chiller.

For the period after the remaining life of the old chillers and before the end of life for the new chillers, the calculation is performed as described, except the efficiency that was used for the old chiller is replaced by the baseline efficiency.

### ***Method for Calculating Demand Savings***

The demand savings calculation is described in the previous paragraph

### ***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are a combination of existing chillers and those required by the Ct Building Code (for electric chillers). These efficiencies are shown in Table 2.2.1.A in the Appendix.

### ***Compliance Efficiency from which incentives are calculated***

The chiller rating at ARI conditions must meet a minimum efficiency to qualify for an incentive. Compliance efficiency is set to meet DPUC source BTU requirement.

| **Cooling System** | **Comfort Cooling (IPLV*)** | **Process Cooling (IPLV*)** |
|---|---|---|
| **Water-cooled** | | |
| < 150 tons | 1.6 COP | 2.0 COP |
| ≥ 150 & < 300 Tons | 1.7 COP | 2.2 COP |
| ≥ 300 Tons | 2.0 COP | 2.5 COP |
| **Air -cooled** | | |
| Any Size | 0.9 COP | 1.2 COP |
| * This requirement may be modified based on the amount of heat recovery. | | |

### ***Operating Hours***

A single value for operating hours is not used. As described above, custom hourly calculations are made for each customer.

***Total Cost***

Total cost will be based on site specific information.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The Non-electric fossil fuel benefit for this measure would be negative. The ‘savings’ would include any gas savings from the heat recovery minus the additional gas consumption from the engine. This would be estimated on a site specific basis.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

Additional annual O&M costs would be added maintenance costs of the engine. These would be estimated on a site specific basis.

***Revision Number***

01

## 3.3.1 CUSTOM MEASURE

***Description of Measure***

This measure is used for C&I Retrofit installations not covered by another specific measure.

***Method for Calculating Energy Savings***

Energy savings are calculated on a custom basis for each customer's specific situation. The savings are the difference in energy usage between the before and after conditions.

***Method for Calculating Demand Savings***

Measures may be lumped into two significantly different categories:
1.) Temperature-dependent (HVAC measures that vary with ambient temperature),
2.) Measures that are not temperature-dependent (process, lighting, time control).

Temperature-dependent methodologies:

The methodology used to determine the demand savings for temperature-dependent measures will depend on the type of analysis used to estimate the savings. Savings from temperature-dependent measures are typically determined by either full load hour analysis, bin temperature analysis, or a detailed computer simulation. The following will be the procedure used to estimate the demand savings for these measures:

When annual savings are calculated using a full load hour analysis, an appropriately derived (for measure and peak time period [On-Peak, Seasonal]) coincidence factor will be used for a measure that has a connected load that can be determined from rated or nameplate data. Demand savings will be the connected load kW savings times the appropriate coincidence factor.

When using a temperature bin analysis to calculate the energy savings, the demand (kW) savings are averaged over the appropriate temperature bins (On-Peak, Seasonal).

When a computer simulation is used to calculate savings, the demand savings will be averaged over the appropriated peak time period (On-Peak, Seasonal).

Non-Temperature-dependent measures:

Demand savings for measures that are not temperature-dependent will be determined by either the coincidence factors from Table 1.1.1 or the average estimated savings over the appropriate peak time periods (On-Peak, Seasonal). For example, for a process VFD measure, the savings will depend on cycling of the load. This cycling may occur many times during an hour. If the process is operating throughout the Seasonal summer period, the average demand savings will be:

(annual kWh savings)/(annual equivalent full load hours of operation).

If the process is operated only a portion of that time period the demand savings will be prorated based on that portion.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Compliance Efficiency from which incentives are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis.

***Total Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits are analyzed on a case-by-case basis.

***Notes & References***

“ 2005 Coincidence Factor Study” 7-20-06 by RLW Analytics.

***Revision Number***

09

# 3.4.1 C&I COOLER NIGHT COVERS

***Description of Measure***

Installation of retractable covers for open-type refrigerated display cases. The covers are deployed during the unoccupied times in order to reduce the energy loss.

***Method for Calculating Energy Savings***

S = W*H*F

S = Savings, kWh per year.
W = Width of the opening that the covers protect, ft.
H = Hours per year the covers are in use.
F = Savings factor based on the temperature of the case, kW/ft;

| | |
|---|---|
| Low temperature (-35F to -5F) | F = 0.1 kW/ft |
| Medium temperature (0F to 30F) | F = 0.06 kW/ft |
| High temperature (35F to 55F) | F = 0.04 kW/ft |

These savings values are based on a study by Southern California Edison.
Southern California Edison (SCE) conducted this test at its state-of-the-art Refrigeration Technology and Test Center (RTTC), located in Irwindale, CA. The RTTC's sophisticated instrumentation and data acquisition system provided detailed tracking of the refrigeration system's critical temperature and pressure points during the test period. These readings were then utilized to quantify various heat transfer and power related parameters within the refrigeration cycle. The results of SCE's test focused on three typical scenarios found mostly in supermarkets.

***Method for Calculating Demand Savings***

There are no demand savings for this measure because the covers will not be in use during the peak period.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

"Effects Of The Low Emissivity Shields On Performance And Power Use Of A Refrigerated Display Case" *Southern California Edison Refrigeration Technology and Test Center Energy Efficiency Division* August 8, 1997.

***Revision Number***

00

## 3.4.2 C&I EVAPORATOR FAN CONTROLS

***Description of Measure***

This measure is applicable to walk-in coolers and freezers that have evaporator fans that run constantly. The measure adds a control system to an existing facility. The control system shuts off the evaporator fans when the cooler's thermostat is not calling for cooling.

***Method for Calculating Energy Savings***

A custom calculation is performed for each facility.

S = N*P*H*factors

S = energy savings, kWh
N = Number of fans
P = Fan power, kW
H = Hours per year the fans are shut off
Factors = Other variables to take into account the motor efficiency, the number of phases, and the compressor efficiency

***Method for Calculating Demand Savings***

KW = C*P

KW = kW reduction from the summer peak
C is the diversity factor of 10%
P = Fan power, kW

***Baseline Efficiencies from which savings are calculated***

The baseline is 24-hour operation of the fans.

***Operating Hours***

Hours per year the fans are shut off.

***Total Cost***

This is based on standard prices for the equipment that is installed.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

00

## 3.4.3 C&I EVAPORATOR FANS MOTOR REPLACEMENT

***Description of Measure***

This measure is for the replacement of the evaporator fan motors in the evaporator units of walk-in or reach-in coolers and freezers. The replacement fan motors are high-efficiency electrically commutated motors (ECM), which require only 60% of the power of normally-installed shaded-pole motors. The evaporator fans normally operate full time, 8760 hours per year.

***Method for Calculating Energy Savings***

A custom calculation is performed for each facility.

S = N*P*H*Factor

S = energy savings, kWh
N = Number of fans
P = Original fan power, kW
Fan power is determined from a measurement of amps and volts, if the HP is unknown.
H = 8760, the number of hours in a year
Factor = Other variables to take into account the motor efficiency improvement and the compressor efficiency. For walk-in cooler applications, the compressor variable of 1.63 is based on a compressor efficiency of 2.25 kW/ton, and the savings from using EC motors is 40%. The overall factor is thus 0.65. Freezer and reach-in applications are not yet offered, and their factors will be determined at the time of the offering.

***Method for Calculating Demand Savings***

KW = 0.6*P

KW = kW reduction from the summer peak
P = Original fan power, kW
0.6 = the reduced power required by the EC motors.

Note – there is no coincidence factor needed in the formula, because the fans are always operating, and the peak is reduced by the full kW reduction.

***Operating Hours***

These fans operate continuously 8760 hours per year.

***Total Cost***

The total cost is based on standard prices for the equipment that is installed.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

01

# SMALL BUSINESS

# 4.1.1 SMB STANDARD LIGHTING

***Description of Measure***

This measure provides an incentive to small businesses to replace inefficient lighting with efficient lighting.

***Method for Calculating Energy Savings***

KWh savings, $S = S_R + S_c$

$S_R$, kWh = savings from retrofit of reduced-wattage lamps,
$S_c$, kWh = savings from reduced cooling

$S_R = (kW_B - kW_A)\ H$

$S_R$ = Energy savings, kWh/year
$kW_B$ = The total power usage of the lighting fixtures that are being replaced, kW.
$kW_A$ = The total power usage of the new lighting fixtures that are being installed, kW.
H = The number of hours during which the lighting is used at the facility, hours/year.

**$S_c$** Calculation of lighting kWh savings due to the reduced cooling required to remove excess heat produced by the lighting fixtures. This is a simplified version of the method used in C&I Section 2.1.1

$S_c$ = Additional savings due to the reduced cooling energy required to remove the energy from lighting, kWh per year.

$$S_C = \frac{(S_R) \bullet F}{COP}$$

F = Fraction of annual kWh energy savings that must be removed by the cooling system, as determined from the table below (If the building area is unknown, F can be taken to be 0.5, which is characteristic of the size of most Small Business facilities):

| Building Area, A, Sq ft | F |
|---|---|
| < 2,000 | 0.48 |
| 2,000 – 20,000 | $0.48 + \frac{0.195(A - 2{,}000)}{18{,}000}$ |
| >20,000 | 0.675 |

COP = 2.4

The source of the equation for $S_c$ and the derivation of the values for F and COP is from “Calculating Lighting and HVAC Interactions,” Ashrae Journal 11-93 as used by KCPL.

***Method for Calculating Demand Savings***

$$KW = \frac{D \bullet (S_P + 0.34 S_o)}{H}(1 + G / COP)$$

D is the peak factor taken from Table 1.1.1.

G = 0.73, and is the estimated lighting energy heat to space, based on modeling results.

0.34 is a diversity factor used to estimate the demand effect due to occupancy sensors.

H = the number of hours used in the energy savings calculation.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Compliance Efficiency from which incentives are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis, or the default facility hours from Table 2.0.0 are used.

***Total Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Space heating increase from reduced lighting load. Annual Fossil fuel Savings = -0.00079 MBTU's per annual kWh saved.
Based on August 22, 2003 Memorandum from Optimal energy, Inc..

***Non-Electric Benefits - Annual O&M Cost Adjustments***

O&M savings are due to the installation of new equipment. O&M Savings = $0.003667 per annual kWh saved.
Based on August 22, 2003 Memorandum from Optimal energy, Inc..

***Revision Number***

06

## 4.1.2 REFRIGERATOR LED

***Description of Measure***

This measure calculates the savings when older fluorescent lighting in commercial display refrigerators, coolers and freezers is replaced with LED systems intended for this application.

***Method for Calculating Energy Savings***

S = KW* H

S = Energy savings, kWh/year
KW = the total kW savings of the refrigeration package, as defined in the next section.
H = The number of hours during which the lighting is used at the facility, hours/year.

***Method for Calculating Demand Savings***

KW = ($kW_B$ –$kW_A$)* Compressor factor

KW = the total kW savings of the refrigeration package, including the kW reduction due to the fixture replacement, and the reduced operation of the compressor due to not having to remove the excess lighting energy.
$kW_B$ = The total power usage of the lighting fixtures that are being replaced, kW.
$kW_A$ = The total power usage of the new lighting fixtures that are being installed, kW.
Compressor factor = 1.51 for coolers and 1.65 for freezers. The factors are based on effective refrigeration compressor EER values of 6.7 and 5.25 Btu/Wh, respectively.

Note: All of the kW savings associated with display refrigeration occur at the peak times because the lights are always on during the peak.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis, or the default facility hours are used from Table 2.0.0.

***Incremental Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

01

## 4.2.1 SMB CUSTOM

***Description of Measure***

This measure is used for Small Business installations not covered by another specific measure.

***Method for Calculating Energy Savings***

Energy savings are calculated on a custom basis for each customer's specific situation. The savings are the difference in energy usage between the before and after conditions.

***Method for Calculating Demand Savings***

Demand savings are calculated on a custom basis for each customer's specific situation.
The savings is the difference in power demand between the before and after conditions that would occur due to the installation of the measure at the time of the electric system peak.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Compliance Efficiency from which incentives are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis.

***Total Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

02

## 4.2.2 SMB AC TUNEUP

***Description of Measure***

This measure encourages users of Air Conditioning equipment to procure maintenance for their equipment from a service organization that uses a computer-based diagnostic tool. The computer-based diagnostic tool is the property of a third-party vendor, and analysis of the data is part of the service the vendor provides. Use of the computer diagnostics helps to ensure that the service is appropriate and complete.

***Method for Calculating Energy Savings***

The kW savings for each customer is multiplied by the that facility's specific EFLH value.

KWh = kW*EFLH

KWh = kWh energy savings per year
KW = kW savings
EFLH = Equivalent full-load hours of operation per year, based on facility type or customer-specific information.

***Method for Calculating Demand Savings***

The vendor provides, for each customer, the size of the equipment, the S/EER rating, and an Efficiency Index (EI) factor measured both before and after the tuneup activity. The EI is the ratio of the measured efficiency value to the rated efficiency value. The EI is used to calculated the before and after kW required by the equipment.

$$kW = \left(\frac{S}{1000SEER}\right)\left(\frac{1}{EI_B} - \frac{1}{EI_A}\right)D$$

KW = kW savings
S = Size of equipment, Btu/hr
SEER = Rating of equipment, Btu/Watt-hour
$EI_B$ = EI before maintenance was performed
$EI_A$ = EI after maintenance was performed
1000 = Conversion from Watts to kW

$kW_p$ = kw *D

$kW_p$ = kW peak demand savings

D = Peak factor from Table 1.1.1

***Baseline Efficiencies from which savings are calculated***

No baseline is used for the energy savings; the savings are specific to each customer.

***Compliance Efficiency from which incentives are calculated***

Incentives are not calculated based on the improvement of efficiency; they are based on a uniform payment for each piece of equipment that has been serviced.

***Operating Hours***

Each facility type is assigned a default value for EFLH, as shown in Table 2.0.0.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

07

## 4.3.1 SMB EVAPORATOR FAN CONTROLS

***Description of Measure***

This measure is applicable to walk-in coolers and freezers that have evaporator fans that run constantly. The measure adds a control system to an existing facility. The control system shuts off the evaporator fans when the cooler's thermostat is not calling for cooling.

***Method for Calculating Energy Savings***

A custom calculation is performed for each facility.

S = N*P*H*factors

S = energy savings, kwh
N = Number of fans
P = Fan power, kw
H = Hours per year the fans are shut off
Factors = Other variables to take into account the motor efficiency, the number of phases, and the compressor efficiency

***Method for Calculating Demand Savings***

KW = C*P

KW = kW reduction from the summer peak
C is the coincidence factor of 10%
P = Fan power, kW

***Baseline Efficiencies from which savings are calculated***

The baseline is 24-hour operation of the fans.

***Operating Hours***

Hours per year the fans are shut off.

***Total Cost***

This is based on standard prices for the equipment that is installed.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***<u>Revision Number</u>***

03

## 4.3.2 SMB DOOR HEATERS

***Description of Measure***

This measure is applicable to walk-in coolers and freezers that have electric heaters on the doors whose purpose is to prevent condensation from forming. This measure adds a control system to an existing facility whose door heaters operate continuously. The control system shuts off the door heaters when the facility's humidity is too low to allow condensation to occur.

***Method for Calculating Energy Savings***

S = P*6500

S = energy savings, kwh
P = Door heater power, kw
6500 = Hours per year the heaters are shut off

***Method for Calculating Demand Savings***

KW = D*P

KW = kW reduction from the summer peak
D is the estimated diversity factor of 10%
P = Door heater power, kW

***Baseline Efficiencies from which savings are calculated***

The baseline is 24-hour operation of the heaters.

***Operating Hours***

Hours per year the heaters are shut off. These hours were determined from data collected each minute for one year for a number of applications.

***Total Cost***

The total cost is based on standard prices for the equipment that is installed.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

04

## 4.3.3 SMB VENDING MACHINE CENTRAL CONTROLS

***Description of Measure***

This measure is available for vending machines that are controlled by a central controller.

***Method for Calculating Energy Savings***

$S = kW( H_B – H_A)$

S = Energy savings, kwh/year
kW = The total power usage of the vending machines that are being controlled, kW.
$H_B$ = The number of hours before being controlled during which the vending machines are turned on at the facility, hours/year. This value is usually 8760.
$H_A$ = The number of hours after the controls are installed during which the vending machines are turned on at the facility, hours/year.

***Method for Calculating Demand Savings***

There are no demand savings for this measure.

***Baseline Efficiencies from which savings are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Compliance Efficiency from which incentives are calculated***

There are no set baseline and compliance efficiencies. The energy savings are calculated as the difference between what is observed before this measure is installed and what is observed after this measure is installed.

***Operating Hours***

The operating hours are determined on a case-by-case basis.

***Total Cost***

The cost to install the measure.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

02

## 4.3.4 SMB COOLER NIGHT COVERS

***Description of Measure***

Installation of retractable covers for open-type refrigerated display cases. The covers are deployed during the unoccupied times in order to reduce the energy loss.

***Method for Calculating Energy Savings***

S = W*H*F

S = Savings, kWh per year.
W = Width of the opening that the covers protect, ft.
H = Hours per year the covers are in use.
F = Savings factor based on the temperature of the case, kW/ft;

| | |
|---|---|
| Low temperature (-35F to -5F) | F = 0.1 kW/ft |
| Medium temperature (0F to 30F) | F = 0.06 kW/ft |
| High temperature (35F to 55F) | F = 0.04 kW/ft |

These savings values are based on a study by Southern California Edison.
Southern California Edison (SCE) conducted this test at its state-of-the-art Refrigeration Technology and Test Center (RTTC), located in Irwindale, CA. The RTTC's sophisticated instrumentation and data acquisition system provided detailed tracking of the refrigeration system's critical temperature and pressure points during the test period. These readings were then utilized to quantify various heat transfer and power related parameters within the refrigeration cycle. The results of SCE's test focused on three typical scenarios found mostly in supermarkets.

***Method for Calculating Demand Savings***

There are no demand savings for this measure because the covers will not be in use during the peak period.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

"Effects Of The Low Emissivity Shields On Performance And Power Use Of A Refrigerated Display Case" *Southern California Edison Refrigeration Technology and Test Center Energy Efficiency Division* August 8, 1997.

***Revision Number***

00

## 4.3.5 SMB EVAPORATOR FANS MOTOR REPLACEMENT

***Description of Measure***

This measure is for the replacement of the evaporator fan motors in the evaporator units of walk-in or reach-in coolers and freezers. The replacement fan motors are high-efficiency electrically commutated motors (ECM), which require only 60% of the power of normally-installed shaded-pole motors. The evaporator fans normally operate full time, 8760 hours per year.

***Method for Calculating Energy Savings***

A custom calculation is performed for each facility.

S = N*P*H*Factor

S = energy savings, kWh
N = Number of fans
P = Original fan power, kW
    Fan power is determined from a measurement of amps and volts, if the HP is unknown.
H = 8760, the number of hours in a year
Factor = Other variables to take into account the motor efficiency improvement and the compressor efficiency. For walk-in cooler applications, the compressor variable of 1.63 is based on a compressor efficiency of 2.25 kW/ton, and the savings from using EC motors is 40%. The overall factor is thus 0.65. Freezer and reach-in applications are not yet offered, and their factors will be determined at the time of the offering.

***Method for Calculating Demand Savings***

KW = 0.6*P

KW = kW reduction from the summer peak
P = Original fan power, kW
0.6 = the reduced power required by the EC motors.

Note – there is no coincidence factor needed in the formula, because the fans are always operating, and the peak is reduced by the full kW reduction.

***Operating Hours***

These fans operate continuously 8760 hours per year.

***Total Cost***

The total cost is based on standard prices for the equipment that is installed.

***<u>Non-Electric Benefits - Annual Fossil Fuel Savings</u>***

Non-electric benefits have not been identified for this measure.

***<u>Revision Number</u>***

01

# RESIDENTIAL

## 5.1.1 CFL LIGHT BULB (DIRECT INSTALL)

***Description of Measure***

A direct installed screw-based CFL bulb. “Direct installed” bulbs are either supplied to the builder for use in qualifying new homes or installed during the final inspection. Savings do not apply to bulbs that are placed in closets or non-living spaces (attics, unconditioned basements, etc.).

***Method for Calculating Energy Savings***

Annual Energy Savings = $\Delta$ Watts x Hours x 365/1000

Where:
$\Delta$ Watts = 2.4 x CFL wattage. This represents an “incandescent to CFL” wattage ratio of 3.4 to 1.

Hours = 2.6 Hours per day (See Note 1)

365 = days per year

For example, the annual savings for a 20 watt CFL:
Annual kWh = 2.4 x 20 watts x 2.6 hours/day x 365 days / 1000 = 45.5 kWh

Note that actual bulb wattage should be used to calculate energy savings – using a default average could lead to a large margin of error. The following chart can be used to calculate the savings for various size bulbs:

| **CFL Bulb Wattage** | Annual kWh Savings | **CFL Bulb Wattage** | Annual kWh Savings |
|---|---|---|---|
| **7** | 15.9 | **19** | 43.3 |
| **8** | 18.2 | **20** | 45.6 |
| **9** | 20.5 | **21** | 47.8 |
| **10** | 22.8 | **22** | 50.1 |
| **11** | 25.1 | **23** | 52.4 |
| **12** | 27.3 | **24** | 54.7 |
| **13** | 29.6 | **25** | 56.9 |
| **14** | 31.9 | **26** | 59.2 |
| **15** | 34.2 | **27** | 61.5 |
| **16** | 36.4 | **28** | 63.8 |
| **17** | 38.7 | **29** | 66.1 |
| **18** | 41.0 | **30** | 68.3 |

***Method for Calculating Demand Savings***

The demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Baseline is assumed to be an incandescent light source with a wattage which is 3.4 times higher than the wattage of the CFL bulb. For instance, it's assumed that a 75 Watt incandescent is "equivalent" to a 22 Watt CFL (22 x 3.4 = 75). For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star CFL Bulb.

***Operating Hours***

2.6 Hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$3.00

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$4.00 per bulb one time benefit. Estimate based on current cost of incandescent bulbs that would be used in place of one CFL.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

05

## 5.1.2 CFL FXTURES (NEW HOMES)

***Description of Measure***

An Energy Star hardwired fluorescent fixture with pin based bulbs. Fixtures with screw-based (CFL) bulbs are treated as CFL bulbs for savings calculations.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:

Δ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day (Note 1)
365 = days per year

For example, the annual savings for a 25 watt fixture:

Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh by the peak demand factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent fixture with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star hard-wired fixture with equivalent lumen output.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$10

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$14.00 (one-time benefit per fixture). Estimate based on added cost of using incandescent bulbs over the life of the measure.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

02

## 5.2.1 SEER 14 MIN AC

***Description of Measure***

Central AC system with rated efficiency of 14 SEER or higher.

***Method for Calculating Energy Savings***

**A. New Construction:**

Annual Energy Savings = 500 x size (1/13 – 1/SEER) / 1000

Where:

500 = expected annual full-run hours (Note 1).
Size = size of system in Btu
13 = assumed SEER (efficiency) of baseline equipment.
SEER = rated SEER (efficiency) of efficient equipment

For example, for a 3 ton (36,000 Btu) 14 SEER system, the annual kWh savings would be = 500 x 36,000 x (1/13 – 1/14) / 1000 = 98.9 kWh.

The following chart can be used as a reference to look up the savings for new units:

| **Size** | **14 SEER** | **15 SEER** | **16 SEER** | **17 SEER** |
|---|---|---|---|---|
| 1 ton | 33.0 | 61.5 | 86.5 | 108.6 |
| 2 ton | 65.9 | 123.1 | 173.1 | 217.2 |
| 3 ton | 98.9 | 184.6 | 259.6 | 325.8 |
| 4 ton | 131.9 | 246.2 | 346.2 | 434.4 |
| 5 ton | 164.8 | 307.7 | 432.7 | 543.0 |

*Expected annual kWh cooling savings for various sizes and efficiency of units*

Note 1: The above chart on energy savings also applies to the Ductless Mini Splits Heat Pump equipments.
Note 2: For multi-speed units, a weighted average of the high speed and low speed efficiencies should be used. Assume 70% on low speed and 30% on high speed.

**B. Early Retirement:**

If the contractor identifies an old central air unit still working and the customer agrees to replace it then a savings can be claimed for removing old unit and installing an Energy Star Unit. The following chart can be used as a reference to look up the savings for Early Retirement of old units:

Annual Energy Savings = 500 x size (1/Old SEER – 1/New SEER) / 1000

Where:

500 = expected annual full-run hours (Note 1).
Size = size of system in Btu
Old SEER = Rated SEER (efficiency) of the old unit being replaced.
New SEER = Rated SEER (efficiency) of efficient equipment.

Table: Annual Energy savings in kWh per ton

| | | Old Existing Equipment SEER | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **7.0** | **7.5** | **8.0** | **8.5** | **9.0** | **9.5** | **10.0** |
| **New Equipment SEER** | **13.0** | 395.60 | 338.46 | 288.46 | 244.34 | 205.13 | 170.04 | 138.46 |
| | **13.5** | 412.70 | 355.56 | 305.56 | 261.44 | 222.22 | 187.13 | 155.56 |
| | **14.0** | 428.57 | 371.43 | 321.43 | 277.31 | 238.10 | 203.01 | 171.43 |
| | **14.5** | 443.35 | 386.21 | 336.21 | 292.09 | 252.87 | 217.79 | 186.21 |
| | **15.0** | 457.14 | 400.00 | 350.00 | 305.88 | 266.67 | 231.58 | 200.00 |
| | **15.5** | 470.05 | 412.90 | 362.90 | 318.79 | 279.57 | 244.48 | 212.90 |
| | **16.0** | 482.14 | 425.00 | 375.00 | 330.88 | 291.67 | 256.58 | 225.00 |

For early retirement, the measure life is 18 years. However, the first five years savings are based on the old unit verses an energy star unit (assumes unit would have been installed for another 5 years) and the remaining 13 years savings are based on the new energy star unit verses the baseline. For example, if a 3 ton SEER 8.0 unit was retired and replaced with a new SEER 15 unit, the lifetime savings would be 5x(1050 kWh) + 13x(184.6kWh)=3450 kWh.

Note: Retirement savings may only be claimed if retirement is program induced.

***<u>Method for Calculating Demand Savings</u>***

Annual kW = size (1/11 – 1/New EER) / 1000

Where:

Size = size of system in Btu/hr
EER for a baseline SEER 13 unit = 11
New EER = Rated EER (Energy Efficiency Ratio) of efficient equipment.

***<u>Baseline Efficiencies from which savings are calculated</u>***

A 13 SEER (code minimum) system.

***<u>Compliance Efficiency from which incentives are calculated</u>***

14 SEER or higher (Note 1).

***<u>Operating Hours</u>***

500 hours per year.

***Incremental Cost***

$100 per SEER unit per ton above 13. For example, a 3 ton 15 SEER would have an assumed incremental cost of $600.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

Note 1. Estimated based on *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*, RLW Analytics, December 2002,
and supported by ASHRAE hours of use when corrected for oversizing.

***Revision Number***

05

# 5.2.2 HEAT PUMP

***Description of Measure***

A heat pump with a heating season performance factor (HSPF) of 8.5 or higher. Note only the heating savings is presented here; cooling savings from an efficient heat pump is the same as the cooling savings for an efficient air conditioner. Utilize methodology in measure 5.2.1 in this manual to determine cooling savings if unit is rated in SEER and 5.3.6 if unit is rated in EER.

***Method for Calculating Energy Savings***

**A. New Construction:**

Annual Energy (heating) Savings = 1,500 x Size (1/7.7 – 1/HSPF) / 1000

Where:

1,500 = estimated annual full-run hours
Size = size of system in Btu
7.7 = assumed efficiency of baseline equipment (HSPF Baseline)
HSPF = rated Heating Season Performance Factor of efficient equipment

For example, for a 3 ton (36,000 Btu) 9 HSPF system, the annual kWh savings would be = 1,500 x 36,000 x (1/7.7 – 1/9) / 1000 = 1,013 kWh.

The following chart can be used as a reference to look up the savings for various sizes and efficiencies:

| Size | 8.5 | 9 | 9.5 |
|---|---|---|---|
| 1 ton | 220 | 338 | 443 |
| 2 ton | 440 | 675 | 886 |
| 3 ton | 660 | 1,013 | 1,329 |
| 4 ton | 880 | 1,351 | 1,772 |
| 5 ton | 1,100 | 1,688 | 2,215 |

*Expected annual kWh heating savings for various sizes and efficiency of units*

Note 1: The above chart on energy savings also applies to Ductless Mini Splits Heat Pump equipments.
Note 2: For multi-speed units, a weighted average of the high speed and low speed efficiencies should be used. Assume 70% on low speed and 30% on high speed.

**B. Early Retirement:**

The following Table shows the annual energy savings from the installation of old existing equipments with new Energy Star rated heat pumps.

Where:

1,500 = Estimated annual full-run hours
Size = Size of system in Btu
Old HSPF = Heating Season Performance Factor of old existing equipment
New HSPF = Heating Season Performance Factor of new Energy Star equipment

If unit heating efficiency is a COP then multiply COP by 3.41 to get HSPF

Annual Energy (heating) Savings = 1,500 x Size (1/Old HSPF – 1/New HSPF) / 1000

Table: Annual energy savings in kWh per ton

| | | **Old Existing Equipment HSPF** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **5.0** | **5.2** | **5.4** | **5.6** | **5.8** | **6.0** | **6.2** | **6.4** | **6.6** | **6.8** | **7.0** |
| **New Equipment HSPF** | **8.0** | 1350.0 | 1211.5 | 1083.3 | 964.3 | 853.4 | 750.0 | 653.2 | 562.5 | 477.3 | 397.1 | 321.4 |
| | **8.2** | 1404.9 | 1266.4 | 1138.2 | 1019.2 | 908.3 | 804.9 | 708.1 | 617.4 | 532.2 | 451.9 | 376.3 |
| | **8.4** | 1457.1 | 1318.7 | 1190.5 | 1071.4 | 960.6 | 857.1 | 760.4 | 669.6 | 584.4 | 504.2 | 428.6 |
| | **8.6** | 1507.0 | 1368.5 | 1240.3 | 1121.3 | 1010.4 | 907.0 | 810.2 | 719.5 | 634.2 | 554.0 | 478.4 |
| | **8.8** | 1554.5 | 1416.1 | 1287.9 | 1168.8 | 1058.0 | 954.5 | 857.8 | 767.0 | 681.8 | 601.6 | 526.0 |
| | **9.0** | 1600.0 | 1461.5 | 1333.3 | 1214.3 | 1103.4 | 1000.0 | 903.2 | 812.5 | 727.3 | 647.1 | 571.4 |

For early retirement, the measure life is 18 years. However, the first five years savings are based on the old unit verses an energy star unit (assumes unit would have been installed for another 5 years) and the remaining 13 years savings are based on the new energy star unit verses the baseline. For example, if a 3 ton HSPF 6.0 unit was retired and replaced with a new HSPF 9.0 unit, the lifetime savings would be 5x(3000 kWh) + 13x(1013kWh)=3450 kWh.

Note: Retirement savings may only be claimed if retirement is program induced.

### C. Electric Resistance to Air Source Heat Pump Energy Savings:

Table: Annual energy savings in kWh per ton replacing Electric Resistance HP to Energy Star rated Heat Pump.

| | | **Old Electric Resistance Unit COP=1 (HSPF=3.4)** |
|---|---|---|
| **New Heat Pump HSPF** | **8.0** | 3028.6 |
| | **8.2** | 3083.5 |
| | **8.4** | 3135.7 |
| | **8.6** | 3185.6 |
| | **8.8** | 3233.1 |
| | **9.0** | 3278.6 |

## *Method for Calculating Demand Savings*

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for winter heating or summer cooling found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

7.7 HSPF (code minimum) heat pump. In case of Retrofit the baseline for energy savings calculation is the HSPF rating of the old existing heat pump.

***Compliance Efficiency from which incentives are calculated***

8.5 or higher HSPF heat pump (Note 1)

***Operating Hours***

1500 hours per year

***Incremental Cost***

$400 per ton.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

03

# 5.2.3 GEOTHERMAL HEAT PUMP

***Description of Measure***

Groumd source heat pump (GSHP) systems. GSHP systems (or "geothermal"), supply heating, cooling, and in some cases water heating (desuperheater or full hot water capability). The savings from those three end-uses are presented separately

***Method for Calculating Energy Savings***

The following table was developed from the results of "HVAC Systems in an Energy Star Home: Owning & Operating Costs", Johnson Research, LLC. The values in the table are given in units per ton of installed cooling capacity.

| **Heating Consumption** | | | |
|---|---|---|---|
| **Heating System** | **Consumption** | **Engineering Units** | **Efficiencies** |
| Electric resistance | 5,971 | kWh/Ton | 100% |
| Air Source Heat Pump | 2,504 | kWh/Ton | 7.7 HSPF |
| Oil Furnace | 265 | Gallons/Ton | 80% AFUE |
| | 195 | kWh/Ton | |
| Gas Furnace | 344 | Therms/Ton | 78% AFUE |
| | 240 | kWh/Ton | |
| GSHP | 1,660 | kWh/Ton | 4 COP |
| **Note: Tonnage based on cooling capacity of Geothermal Unit** | | | |

| **Cooling Consumption and Summer Demand** | | | |
|---|---|---|---|
| **System** | **Cooling (kWh/Ton)** | **Efficiency** | **Summer Demand (kW/Ton)** |
| Electric resistance | 807 | 13 SEER | 1.05 |
| Air Source Heat Pump | 807 | 13 SEER | 1.05 |
| Oil Furnace | 807 | 13 SEER | 1.05 |
| Gas Furnace | 807 | 13 SEER | 1.05 |
| GSHP | 541 | 19.4 EER | 0.65 |
| **Note: Tonnage based on cooling capacity** | | | |

| **Water Heating Consumption** | | |
|---|---|---|
| System | Consumption | Units |
| Electric resistance | 4,305 | kWh |
| Oil | 154 | Gallons |
| Gas | 215 | Therms |

Annual kWh savings = annual kWh Heating savings + annual kWh Cooling savings +annual kWh water heating savings

The non-commissioning savings calculations below are shown for information only. Savings claimed by this measure will only be the commissioning savings calculated below. It is assumed that customers would have installed geothermal without program intervention.

**1) Natural Gas Baseline.**

a) Heating (kWh) Savings = INCCAP*(240 – (1,660)*(4 /INCOP))

b) Cooling (kWh) Savings = INCCAP*(807 – (541)*(19.4 /INEER))

c) Water Heating (kWh) Savings = 0 – (4,305/INWHCOP)

**2) Oil Baseline:**

a) Heating (kWh) Savings = INCCAP*(195 – (1,660)*(4 /INCOP))

b) Cooling (kWh) Savings = INCCAP*(807 – (541)*(19.4 /INEER))

c) Water Heating (kWh) Savings = 0 – (4,305/INWHCOP)

**3) Electric Resistance Baseline:**

a) Heating (kWh) Savings = INCCAP*(5,971 – (1,660)*(4 /INCOP))

b) Cooling (kWh) Savings = INCCAP*(807 – (541)*(19.4 /INEER))

c) Water Heating (kWh) Savings = 4,304 – (4,305/INWHCOP)

**4) Air Source Heat Pump Baseline:**

a) Heating (kWh) Savings = INCCAP*(2,504 – (1,660)*(4 /INCOP))

b) Cooling (kWh) Savings = INCCAP*(807 – (541)*(19.4 /INEER))

c) Water Heating (kWh) Savings = 4,304 – (4,305/INWHCOP)

INCCAP = installed nominal cooling capacity in tons

INCOP = GSHP's rated heating efficiency in COP. System must be tested to verify unit is operating at rated efficiency.

INEER = GSHP's rated Cooling efficiency in EER. System must be tested to verify unit is operating at rated efficiency.

INWHCOP = GSHP's rated water heating efficiency in COP
Use 1 for electric resistance, use 1.2 for desuperheater

**The baseline is assumed to be GSHP. Therefore the only claimed savings from this measure would be from the commissioning requirement (and perhaps shell savings).**

Commissioning savings are assumed to be 10% of the theoretical usage:

Heating kWh savings = (166 kWh/ton)(ICCAP)(4)/(INCOP)

Cooling kWh savings = (54.1 kWh/ton)(ICCAP)(19.4)/(INEER)

***Method for Calculating Demand Savings***

The savings calculations below are shown for information only. Savings claimed by this measure will only be the commissioning savings calculated above. It is assumed that customers would have installed geothermal without program intervention.

**For retrofit Projects:**
Summer Demand savings = Cooling (kW) savings + Water heating (kW) savings

a) Cooling (kW) savings = CF*INCCAP*(1.05 – 0.62*19.4/INEER)

b) Water Heating (kW) savings = (Water heating (kWh) savings) / 8,760

**For New construction projects:**

a) Cooling (kW) demand savings = CF*INCCAP*0.062*19.4/INEER

CF = Residential central cooling coincidence factor

***Baseline Efficiencies from which savings are calculated***

It is assumed that the home would have a ground source heat pump without program intervention. However, it is assumed that the system would not be commissioned. Therefore, the baseline is an uncommissioned ground source heat pump, and savings is based on the commissioning (10%) savings (in addition to any shell savings through the Residential New Construction Program).

System Replacement: The existing system will determine the heating and water heating baseline. Central air with a 13 SEER is the assuming cooling baseline.

***Incremental Cost***

Typically, incremental cost will range from $8,000 to $20,000 based on system size and system baseline. A rough estimate of incremental cost would be about $3,000 per ton.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Fossil Fuel savings = fossil fuel heating savings + Fossil fuel water heating savings

Natural Gas Baseline:

Fossil fuel savings (therms) = INCCAP*344 + 215

Oil Baseline:
Fossil Fuel savings (gallons) = INCCAP*298 + 154

***Revision Number***

04

# 5.2.4 COMMISSIONING

***Description of Measure***

This measure applies to the verification of proper design and installation of central air conditioning and heat pump systems.
This savings estimate was developed by UI and CL&P in March, 2006 and is consistent with description of the savings made in Docket No. 05-07-14PH01 (EL-005) Filing made with Department on March 27, 2006.

***Method for Calculating Energy Savings***

Annual energy Savings (kWh) = (Efficiency savings) + (fan savings from reduction in ductwork static pressure)

**A) Fan savings (kWh)** = $\frac{\text{(CFM x BWCFM – FW) x EFLH}}{\text{1000 w/kW}}$

note: Fan savings will only be counted if measured air flow is >350 CFM/ton and Measured wattage is < 0.51 /CFM

CFM should be measured using True Flow™ air flow measuring device or other alternative method approved by program administrator. Fan wattage (BWCFM) should be a direct method or calculated based on the fan curve for the unit.

**B) Efficiency Savings (kWh)** = $\frac{\text{12 x Capacity x EFLH}}{\text{SEER}}$ x (1/EIb – 1/EIa)

CFM = System air flow in CFM
BWCFM = baseline watts per CFM (0.510 based on Proctor and Parker 2000)
FW = measured fan wattage
Capacity - Air conditioning units rated capacity in tons
12 - Conversion from tons to kBTU's
SEER - Seasonal energy efficiency ratio (nameplate)
EIb – Efficiency index before (95% based on the average tune-up reading)
EIa – Efficiency index after (output from tool)
EFLH – Equivalent Full Load Hours (assumed to be 500)

**IMPORTANT – The following recommendations must be followed in order for efficiency savings to be valid.**

1) Minimum outdoor temperature must be 55 Degrees F and 65 Degrees F for a TXV System. "Tents" should not be used to increase the ambient temperature around the condensing unit.
2) System must be running for 10 – 15 minutes prior to taking the first (initial) reading.
3) Compressor must be fully loaded (high speed for multi-speed units) and running at steady state efficiency.
4) A reasonable indoor load must be maintained throughout the test or the results. Therefore, return air must be at least 65 degrees F wet bulb and/or 80 degrees F dry bulb temperature.

***Method for Calculating Demand Savings***

Demand Savings (kW) = Efficiency savings (kW) + Fan Savings (kW)

A) Fan savings (kW) = $\dfrac{(\text{CFM x BWCFM} - \text{FW}) \text{ x CF}}{1000 \text{ w/kW}}$

note: Fan savings will only be counted if measured air flow is >350 CFM/ton and Measured wattage is < 0.51 /CFM

B) Efficiency Savings (kW) = $\dfrac{12 \text{ x Capacity x CF}}{\text{SEER x } 0.875}$ x (1/EIb – 1/EIa)

CF – Coincidence factor
0.875 – Conversion from SEER to EER.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the nameplate SEER time the EIb (95%).

***Compliance Efficiency from which incentives are calculated***

An HVAC system that has documented performance testing using the Honeywell Service Assistant.

***Operating Hours***

500 hours for cooling.

***Incremental Cost***

The cost to the contractor for each tune-up is assumed to be $125, but costs may vary based on the contractor and geographic location. Also, $125 is assumed to be the minimum cost and is expected to only cover the diagnostic portion of the test in most situations. If significant problems are uncovered during the diagnostic portion of the test, the cost is expected to rise.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

Note 1. *Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market*, RLW Analytics, Inc. December 2002.

***Revision Number***

04

## 5.2.5 AC SYS TUNE-UP

***Description of Measure***

This measure applies to diagnostic tune-up using the Service Assistant and is based on the measured changes in the efficiency index (EI) as measured with the Service Assistant Tool.

This savings estimate was developed by UI and CL&P in April, 2006.

***Method for Calculating Energy Savings***

$$\text{Annual Energy Savings (kWh)} = \frac{12 \times \text{Capacity} \times \text{EFLH}}{\text{SEER}} \times (1/\text{EIb} - 1/\text{EIa})$$

Capacity - Air conditioning units rated capacity in tons
12 - Conversion from tons to kBTU's
SEER - Seasonal energy efficiency ratio (nameplate)
EIb – Efficiency index before (output from tool)
EIa – Efficiency index after (output from tool)
EFLH – Equivalent Full Load Hours (assumed to be 500)

**IMPORTANT – The following recommendations must be followed in order for savings from a tune-up to be valid.**

1) On the occasion that only one reading is taken or EIa < EIb, the savings defaults to 0 and "deemed" savings is not claimed.
2) Minimum outdoor temperature must be 55 Degrees F and 65 Degrees F for a TXV System. "Tents" should not be used to increase the ambient temperature around the condensing unit.
3) System must be running for 10 – 15 minutes prior to taking the first (initial) reading.
4) Compressor must be fully loaded (high speed for multi-speed units) and running at steady state efficiency.
5) A reasonable indoor load must be maintained throughout the test or the results. Therefore, return air must be at least 65 degrees F wet bulb and/or 80 degrees F dry bulb temperature.
6) Units that have been tuned-up within measure life time period specified in Table 1.4 can not claim additional (double-counted) savings since the savings has already been.

***Method for Calculating Demand Savings***

$$\text{Demand Savings (kW)} = \frac{12 \times \text{Capacity} \times \text{DF}}{\text{SEER} \times 0.875} \times (1/\text{EIb} - 1/\text{EIa})$$

DF – diversity factor
0.875 – Conversion from SEER to EER.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the nameplate SEER multiplied by the EIb.

***Compliance Efficiency from which incentives are calculated***

An HVAC system that has documented performance testing using the Service Assistant.

***Operating Hours***

The full load operating hours for CT are assumed to be 500 hours / year.

***Total Cost***

The cost to the contractor for each tune-up is assumed to be $125, but costs may vary based on the contractor and geographic location. Also, $125 is assumed to be the minimum cost and is expected to only cover the diagnostic portion of the test in most situations. If significant problems are uncovered during the diagnostic portion of the test, the cost is expected to rise.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

07

## 5.2.6 ELECT COMM MOTOR

***Description of Measure***

ECM (electrically commutated motor) furnace fan motor.

***Method for Calculating Energy Savings***

Energy Savings is estimated to be 300 kWh per year heating.

For cooling (if the fan is part of a central cooling system), annual savings is estimated to be 100 kWh. Note that SEER ratings for cooling systems take into account fan power, so the cooling savings for ECM fans may already be captured if savings is claimed based on the SEER of a central air cooling system.

***Method for Calculating Demand Savings***

The demand savings is calculated using peak factors found in Table 1.1.3 in the Appendix.

***Baseline Efficiencies from which savings are calculated***

Permanent split capacitor (PSC) furnace fan motor.

***Operating Hours***

1500 hours per year heating
500 hours per year cooling

***Incremental Cost***

$300 estimated.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

**Negative** non-electric benefit due to increased fossil fuel heating usage (Note 1):
12.0 Therms gas
8.6 gallons oil
13.4 gallons propane

***Notes & References***

Note 1. Furnace with an ECM motor will burn slightly more fuel to compensate for lower heat generated by more efficient fan. Estimate by Joe Swift, Northeast Utilities, 2005 assuming an average fossil fuel efficiency (AFUE) of 85%.

***Revision Number***

04

# 5.2.9 DUCT SEALING

***Description of Measure***

Ducts sealed to reduce outside infiltration. Duct improvements (sealing) should be verified with duct blaster test at 25 Pa using an approved test method. Alternative test methods (subtraction method, flow hood method, delta Q, etc) will generally yield inconsistent results and are not permitted.

Note that REM savings (5.4.1) and BOP savings (5.4.2) includes duct sealing savings. Therefore, this measure does NOT apply to homes that are already claiming savings as one of these measures. This is a stand-alone measure and is not intended to be applied to homes that fall into one of these tracks.

***Method for Calculating Energy Savings***

A) **New Construction:** The results below are engineering estimates of expected savings from verified duct sealing for new construction. This savings does NOT apply to Energy Star Homes. For those homes, savings should be calculated using the UDRH (see 5.4.1 REM Savings).

| | Savings per 1000 Square feet Conditioned Space | | | |
|---|---|---|---|---|
| **Duct Blaster Results** (outside leakage per 100 sq feet conditioned space at 25 Pa) | Heating (MBtu) | Geothermal kWh Savings | Heating (kWh Fan Savings) | kWh (Cooling) |
| 8 | 3.1 | 227 | 25 | 101 |
| 7 | 3.9 | 286 | 31 | 127 |
| 6 | 4.7 | 344 | 38 | 152 |
| 5 | 5.5 | 403 | 44 | 177 |
| 4 | 6.3 | 461 | 50 | 203 |
| 3 | 7.0 | 513 | 56 | 228 |
| 2 | 7.8 | 571 | 62 | 253 |
| 1 | 8.6 | 630 | 69 | 279 |
| 0 | 9.4 | 689 | 75 | 304 |

B) **Retrofit**

Savings for existing ducts that are sealed. Savings must be verified by measuring outside duct leakage at 25 Pascals using standard duct blaster testing procedures.

**Duct Blaster Savings at 25 Pa**

| | **Heating (MBtu)** | Heating (Resistance) | Heating (Heat Pumps) | Heating (Geothermal) | kWh Fan Heating Savings | **kWh (Cooling)** |
|---|---|---|---|---|---|---|
| Average Basement Leakage | 5.2 | 1523 | 762 | 507 | 44 | 159 |
| Average Attic Leakage | 8.1 | 2373 | 1187 | 791 | 65 | 234 |
| Average (basement and attic) | 6.7 | 1948 | 974 | 649 | 55 | 197 |

Savings for 100 CFM at 25 Pa duct leakage reduction

***<u>Method for Calculating Demand Savings</u>***

The demand savings is calculated using peak factors found in Table 1.1.3 in the Appendix.

***<u>Baseline Efficiencies from which savings are calculated</u>***

Ducts that have not been sealed.

***<u>Compliance Efficiency from which incentives are calculated</u>***

Duct sealed to reduce outside leakage.

***<u>Incremental Cost</u>***

Actual cost or $100 per 1000 square feet.

***<u>Non-Electric Benefits - Annual Fossil Fuel Savings</u>***

**A) New Construction:**

The heating savings (above) can be converted to appropriate fossil fuel units of measure

| | Savings per 1000 Square feet Conditioned Space | | | |
|---|---|---|---|---|
| **Duct Blaster Results** (outside leakage per 1000 sq feet conditioned space at 25 Pa) | Heating (MMBtu) | Gallons Oil | Therms Gas | Gallons Propane |
| 8 | 3.1 | 29.5 | 41.7 | 46.3 |
| 7 | 3.9 | 37.1 | 52.2 | 57.9 |
| 6 | 4.7 | 44.8 | 62.5 | 69.4 |
| 5 | 5.5 | 52.4 | 73.0 | 81.1 |
| 4 | 6.3 | 60.0 | 83.3 | 92.7 |
| 3 | 7.0 | 66.7 | 93.9 | 104.3 |
| 2 | 7.8 | 74.3 | 104.3 | 115.8 |
| 1 | 8.6 | 81.9 | 114.7 | 127.5 |
| 0 | 9.4 | 89.5 | 125.1 | 139.0 |

*Estimated savings values are take into account average expected system efficiency of 75%.*
In addition, there may be some non-electric benefits due to better comfort and small system size. However, due to their indeterminate nature, it is difficult to rigorously quantify their value with reasonable certainty.

**B) Retrofit**

**Duct Blaster Savings at 25 Pa**

| | **Heating (MBtu)** | Gallons Oil | Therms Gas | Gallons Propane |
|---|---|---|---|---|
| Average Basement Leakage | 5.2 | 50.0 | 70.0 | 77.8 |
| Average Attic Leakage | 8.1 | 76.9 | 107.6 | 119.6 |
| Average (basement and attic) | 6.7 | 63.5 | 88.9 | 98.7 |
| Savings for 100 CFM at 25 Pa duct leakage reduction | | | | |

*Estimated savings values are take into account average expected system efficiency of 75%.*

***<u>Revision Number</u>***

09

## 5.2.12 HEAT PUMP - DUCTLESS

***Description of Measure***

Ductless heat pumps.

***Method for Calculating Energy Savings***

Heating Savings is calculated using the lesser of the heating capacity of the unit(s) OR the load of the house, the region IV HSPF, and 1500 full load hours. Estimated heating savings should be compared with bill data for reasonableness.

Annual Energy (heating) Savings = 1,500 x Size (1/HSPF(baseline) – 1/HSPF(new)) / 1000

Where:
1,500 = estimated annual full-run hours
Size = size of system in Btu
HSPF = Heating Season Performance Factor

Cooling savings is calculated using the rated SEER and 500 full load hours.

Annual Energy (cooling) Savings = 500 x size (1/SEER(baseline) – 1/SEER(new)) / 1000

Where:
500 = expected annual full-run hours.
Size = size of system in Btu
SEER = Seasonal Energy Efficiency Ratio

***Method for Calculating Demand Savings***

Demand Savings is calculated using the peak factors in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

For retrofit, baseline efficiency is the actual existing efficiency for both heating and cooling. In situations where the actual baseline efficiency us unknown, use the following table:

| Technology | Baseline Retrofit Efficiency | Baseline New Construction |
|---|---|---|
| Electric Resistance Heating | 3.41 HSPF | N/A |
| Heat Pump (heating) | 5.0 HSPF | 7.7 HSPF |
| Window AC | 7.5 SEER/EER | 13 SEER |
| Central AC (or heat pump) Cooling | 10 SEER | 13 SEER |
| NO AC Present | 0 (negative cooling savings) | 13 SEER |

***Operating Hours***

1500 hours heating
500 hours cooling

***Incremental Cost***

For retrofit, the incremental cost is assumed to be $4000 + $2,000*(# of zones-1).
i.e. one zone costs $4,000, two zones cost $6,000 etc. A "zone" is a separate air handler regardless of the number of condensing units.

For new construction, the incremental cost is $500

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

01

# 5.3.1 CFL BULBS (RETAIL)

***Description of Measure***

A screw-based (integrated ballast) compact fluorescent light bulb. Typical CFL wattage is between 9 and 23 watts.

***Method for Calculating Energy Savings***

Gross Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:
Δ Watts = 2.4 x CFL wattage based on a 3.4 wattage ratio (Note 1).
Hours = 2.6 Hours per day (Note 2).
365 = days per year

For example, the annual savings for a 20 watt CFL:
Annual kWh = 2.4 x 20 watts x 2.6 hours/day x 365 days / 1000 = 45.6 kWh

Note that actual bulb wattage should be used to calculate energy savings. See the chart below for gross and net savings for bulbs of various wattages.

The overall realization rate is 76% and includes the effects of spillover, free-ridership and installation rates (Note 2)

The following chart can be used to look up gross (without impact factors) and net (with impact factors) savings for various size bulbs. The gross savings numbers were generated using the savings algorithm above and the net savings numbers were generated by applying the realization rate above to the gross savings:

| CFL Bulb Wattage | Gross Annual kWh Savings | Net Annual kWh Savings | CFL Bulb Wattage | Gross Annual kWh Savings | Net Annual kWh Savings |
|---|---|---|---|---|---|
| 7 | 15.9 | 12.1 | 19 | 43.3 | 32.9 |
| 8 | 18.2 | 13.8 | 20 | 45.6 | 34.6 |
| 9 | 20.5 | 15.6 | 21 | 47.8 | 36.4 |
| 10 | 22.8 | 17.3 | 22 | 50.1 | 38.1 |
| 11 | 25.1 | 19.0 | 23 | 52.4 | 39.8 |
| 12 | 27.3 | 20.8 | 24 | 54.7 | 41.5 |
| 13 | 29.6 | 22.5 | 25 | 56.9 | 43.3 |
| 14 | 31.9 | 24.2 | 26 | 59.2 | 45.0 |
| 15 | 34.2 | 26.0 | 27 | 61.5 | 46.7 |
| 16 | 36.4 | 27.7 | 28 | 63.8 | 48.5 |
| 17 | 38.7 | 29.4 | 29 | 66.1 | 50.2 |
| 18 | 41.0 | 31.2 | 30 | 68.3 | 51.9 |

*Gross and Net Annual Savings for bulbs. Note that the net savings in this chart assumes that sales data is available for the bulb.*

***Method for Calculating Demand Savings***

The demand savings is calculated by multiplying the annual kWh savings by the appropriate peak factors found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Baseline is assumed to be an incandescent light source with a wattage which is 3.4 times higher than the wattage of the CFL bulb. For instance, it's assumed that a 75 Watt incandescent is "equivalent" to a 22 Watt CFL (22 x 3.4 = 75). For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star screw-based bulb with equivalent lumen output.

***Operating Hours***

2.6 Hours per day estimate (Note 1).

***Incremental Cost***

$2.00 assumed average. Range is between $1 and $10, however most bulbs currently in the lighting program are towards the lower end of this price spectrum.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$4.00 per bulb one time benefit. Estimate based on current cost of incandescent bulbs that would be used in place of one CFL.

***Notes & References***

Note 1. Hours of use is an estimate based on various recent evaluation work including: *CFL Metering Study*, (California), KEMA Inc. 2005.

Note 2. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

Note 3. In cases where sales data is not available, a 35% installation rate should be used (half of the current installation rate of 70%) based on an assumption that half of the bulbs with no sales data make it into the marketplace and produce savings.

***Revision Number***

04

## 5.3.2 PORTABLE LAMPS

***Description of Measure***

An Energy Star portable (plug type) light fixture with pin-based bulbs (i.e. table lamp, desk lamp, etc.). Note that torchieres are not included here; rather they are handled as a separate measure.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:

Δ Watts = 2.4 x fixture wattage (3.4 wattage conversion factor).
Hours = 3.2 Hours per day (Note 1)
365 = days per year

For example, the annual savings for a 25 watt fixture:

Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent portable fixture with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way products, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star lamp with equivalent lumen output.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation. Note 1.

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$6.00 one-time benefit per fixture.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

03

## 5.3.3 TORCHIERE

***Description of Measure***

Energy Star torchiere (fixture).

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000 (Note 1)

Where:

Δ Watts = the lesser of 2.4 x fixture wattage (3.4 wattage conversion factor).
**or** 190 – fixture Wattage (Note 2).

Hours = 3.2 Hours per day
365 = days per year

For example, the annual savings for a 55 watt torchiere fixture:

Δ Watts = the lesser of 2.4 x 55 = 132 OR 190 – 55 = 135.
Therefore, Δ Watts = 132 Watts (lesser of the two).

Annual kWh = 132 Watts x 3.2 hours/day x 365 days / 1000 = 154.2 kWh

The overall realization rate is 72.1% and includes free-ridership, spillover and installation rate (Note 1).

The following chart displays gross and net savings for torchieres of various wattages. Linear interpolation can be used to predict savings for wattages that fall between these categories.

| Fluorescent Torchiere Wattage | Delta Watts | Gross Annual kWh Savings | Net Annual kWh Savings *(with 72.1% Realization Rate)* |
|---|---|---|---|
| 25 | 60 | 70.1 | 50.5 |
| 30 | 72 | 84.1 | 60.6 |
| 35 | 84 | 98.1 | 70.7 |
| 40 | 96 | 112.1 | 80.8 |
| 45 | 108 | 126.1 | 90.9 |
| 50 | 120 | 140.2 | 101.1 |
| 55 | 132 | 154.2 | 111.2 |
| 60 | 130 | 151.8 | 109.5 |
| 65 | 125 | 146.0 | 105.3 |
| 70 | 120 | 140.2 | 101.1 |
| 75 | 115 | 134.3 | 96.8 |

*Torchiere Net and Gross Savings by Wattage.*

***Method for Calculating Demand Savings***

The demand savings can be calculated by multiplying the annual savings in kWh by the appropriate peak factors found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent or halogen torchiere with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way products, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star torchiere with equivalent lumen output.

***Operating Hours***

3.2 hours per day.

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$5.00 (one-time benefit per fixture). Estimate based on increased cost of incandescent bulbs that would be used in the baseline case.

***Notes & References***

Note 1. Savings assumptions including impact factors are from the following: *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

Note 2. Public Act 04-85, An Act Concerning Energy Efficiency Standards, July 2004, limits torchiere wattage to 190 Watts. Therefore, the baseline is capped at 190 watts and the $\Delta$ Wattage is limited by this cap.

***Revision Number***

03

# 5.3.4 FIXTURE (HARD WIRED)

***Description of Measure***

An Energy Star hardwired fluorescent fixture with pin based bulbs. Note that fixtures with screw-based (CFL) bulbs are treated as CFL bulbs for savings calculations.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000 (Note 1).

Where:

Δ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day
365 = days per year

For example, the annual savings for a 25 watt fixture:

Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

For fixtures with multiple bulbs, the wattage is the total wattage of all bulbs (not the wattage of one bulb).

***Method for Calculating Demand Savings***

The demand savings can be calculated by multiplying the annual savings in kWh by the appropriate peak factors found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent fixture with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star hard-wired fixture with equivalent lumen output.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$14.00 (one-time benefit per fixture). Estimate based added cost of using incandescent bulbs over the life of the measure.

***Notes & References***

Note 1. Savings assumptions including impact factors are from the following: *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

03

# 5.3.5 CEILING FAN & LIGHTS

***Description of Measure***

Energy Star ceiling fan/light combination.

***Method for Calculating Energy Savings***

Note that only the energy savings from the light is considered. Therefore, savings for this measure is based on the light wattage and is identical to the savings for a light fixture. Fan motor savings is negligible, and cooling savings has not been determined.

Annual Energy Savings = $\Delta$ Watts x Hours x 365/1000 (Note 1).
Where:

$\Delta$ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day
365 = days per year

For example, the annual savings for a qualifying fan/light with a 25 watt light source:

Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

For fans with multiple bulbs, the wattage is the total wattage of all bulbs. For instance, if a ceiling fan has four 20 watt bulbs, the savings would be based on an 80 Watt light source.

***Method for Calculating Demand Savings***

The demand savings can be calculated by multiplying the annual savings in kWh by the appropriate peak factors found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Fan/light combination with an incandescent light source wattage equal to 3.4 times the light source wattage of the Energy Star fan/light combination.

***Compliance Efficiency from which incentives are calculated***

Energy Star fan/light combination with fluorescent light source.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$14.00 (one-time benefit per fixture). Estimate based added cost of using incandescent bulbs over the life of the measure.

***Notes & References***

Note 1. Savings assumptions including impact factors are from the following: *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

03

# 5.3.6 ROOM WINDOW AIR CONDITIONER

***Description of Measure***

Room air conditioners meeting the minimum qualifying efficiencies established by the Energy Star Program that are purchased from vendors participating in negotiated cooperative promotions.

***Method for Calculating Energy Savings***

The savings is the difference in consumption between the new Energy Star unit and the base unit (minimum federal efficiency standard).

Annual kWh Savings = 500 hours * BTU/h Rating * (1/Fed Std EER - 1/Actual EER)/1000W/ kW

**Room AC Annual kWh Savings Based on 500 Hours of Operation**

| **EER Rating >** | **9.7** | **10** | **10.7** | **11** | **11.5** | **12** |
|---|---|---|---|---|---|---|
| | Fed Std | | E-Star min | | | |
| **Btu/h Rating** | | | | | | |
| **5,000** | 0.0 | 7.7 | 24.1 | 30.5 | 40.3 | 49.4 |
| **6,000** | 0.0 | 9.3 | 28.9 | 36.6 | 48.4 | 59.3 |
| | | | | | | |
| **EER Rating >** | **9.8** | **10** | **10.8** | **11** | **11.5** | **12** |
| | Fed Std | | E-Star min | | | |
| **8,000** | 0.0 | 8.2 | 37.8 | 44.5 | 60.3 | 74.8 |
| **10,000** | 0.0 | 10.2 | 47.2 | 55.7 | 75.4 | 93.5 |
| **11,000** | 0.0 | 11.2 | 52.0 | 61.2 | 83.0 | 102.9 |
| **12,000** | 0.0 | 12.2 | 56.7 | 66.8 | 90.5 | 112.2 |
| **13,000** | 0.0 | 13.3 | 61.4 | 72.4 | 98.0 | 121.6 |
| | | | | | | |
| **EER Rating >** | **9.7** | **10** | **10.7** | **11** | **11.5** | **12** |
| | Fed Std | | E-Star min | | | |
| **14,000** | 0.0 | 21.6 | 67.4 | 85.3 | 113.0 | 138.3 |
| **15,000** | 0.0 | 23.2 | 72.3 | 91.4 | 121.0 | 148.2 |
| **16,000** | 0.0 | 24.7 | 77.1 | 97.5 | 129.1 | 158.1 |
| **17,000** | 0.0 | 26.3 | 81.9 | 103.6 | 137.2 | 168.0 |
| **18,000** | 0.0 | 27.8 | 86.7 | 109.7 | 145.2 | 177.8 |

***Method for Calculating Demand Savings***

The demand saving is calculated by multiplying the annual savings by the summer peak demand factor for residential cooling found in Table 1.1.3 in the Appendix.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are the Federal Standards shown in the table above.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiencies are the Energy Star Efficiencies shown in the table above.

***Operating Hours***

The full load operating hours for CT are assumed to be 500 hours per year.

***Incremental Cost***

The incremental cost of a new Energy Star unit is assumed to be $50.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Non-Electric Benefits - Annual Water Savings***

Non-electric benefits have not been identified for this measure.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

Non-electric benefits have not been identified for this measure.

***Revision Number***

06

# 5.3.7 CLOTHES WASHER

## *Description of Measure*

Residential clothes washers meeting the minimum qualifying efficiency standards establishes under the Energy Star Program.

## *Method for Calculating Energy Savings*

The savings shown below for program planning purposes is the average for washers based on an expected fuel mix.

**Table1: Annual Energy Savings**

| Clothes Washers | MEF | Incremental Cost | Electric Water Heater | | Fossil Fuel Water Heater | | Annual Water savings | 20% | 80% | 24% | 48% | 8% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Savings | | Savings | | (gallons) | Mix | | | | |
| | | | Electric (kWh) | Fossil Fuel (Btu) | Electric (kWh) | Fossil Fuel (Btu) | | Electric (kWh) | Fossil Fuel (Btu) | Natural Gas (Ccf) | Oil (Gal) | Other (Btu) |
| **Savings - New Units** | | | | | | | | | | | | |
| Base Line | 1.26 | $ - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy Star | 1.72 | $ 290.00 | 254 | 0 | 15.0 | 900,000 | 6,993 | 62.8 | 720,000 | 2.16 | 3.09 | 72,000 |
| Tier 3 | 2.20 | | 609 | 0 | 22.4 | 1,680,531 | 7,397 | 139.7 | 1,344,425 | 4.03 | 5.76 | 134,442 |
| | | | | | | | | | | | | |
| **Early Retirement** | | | | | | | | | | | | |
| Typical washer | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy Star | 1.72 | | 565 | 0 | 50.0 | 3,900,000 | 9,932 | 153.0 | 3,120,000 | 9.36 | 13.37 | 312,000 |
| Tier 3 | 2.20 | | 920 | 0 | 57.4 | 4,680,531 | 10,336 | 229.9 | 3,744,425 | 11.23 | 16.05 | 374,442 |

For new units, the weighted average savings for tier 3 washers and all fuel types is 139.7 kwh compared to the federal minimum baseline.

For early retirement, the measure life is 14 years. However, the first four years savings (229.9 kWh weighted all fuels) are based on the old washer (typical) verses a tier 3 washer (assumes old washer would have been used another 4 years) and the remaining 10 years savings (139.7 kWh weighted all fuels) are based on the new Tier 3 washer verses the baseline. This assumes that the customer replaces the existing unit with a Tier 3 model.

Note: Retirement savings may only be claimed if retirement is program induced.

## *Method for Calculating Demand Savings*

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for winter or summer domestic water heating found in Appendix Table 1.1.3.

## *Baseline Efficiencies from which savings are calculated*

The baseline efficiency is the efficiency of a washer meeting the federal minimum std.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency to receive an incentive is that of an Energy Star Washer.

***Operating Hours***

The number of wash cycles per year is used instead of the operating hours for the washing machine. The number of cycles per year is 392.

***Incremental Cost***

| Clothes Washers | MEF | Incremental Cost ($) |
|---|---|---|
| Base Line | 1.26 | 0 |
| Energy Star | 1.72 | 250 |
| Tier 3 | 2.20 | 450 |

Source: Survey conducted by Applied Proactive Technologies (APT), Springfield, MA.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Annual Fossil Fuel savings is shown in table above.

***Non-Electric Benefits - Annual Water Savings***

The annual water savings is shown in the table above.

***Notes & References***

Savings were based on minimum federal standard MEF = 1.26, Energy Star MEF = 1.72 And Tier 3 MEF = 2.20 Clothes Washers and an analysis using Energy Star clothes washer savings calculator.
Source: Energy Star Website

***Revision Number***

09

# 5.3.8 DISHWASHER

## ***Description of Measure***

Energy Star Dishwasher

## ***Method for Calculating Energy Savings***

**Table1: Annual Energy Savings**

| **Dishwashers** | **EF** | **Incremental Cost** | **Electric Water Heater** | | **Fossil Fuel Water Heater** | | **Annual Water savings** | **20%** | **80%** | **24%** | **48%** | **8%** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Savings** | | **Savings** | | **(gallons)** | **Mix** | | | | |
| | | | **Electric (kWh)** | **Fossil Fuel (Btu)** | **Electric (kWh)** | **Fossil Fuel (Btu)** | | **Electric (kWh)** | **Fossil Fuel (Btu)** | **Natural Gas (Ccf)** | **Oil (Gal)** | **Other (Btu)** |
| **Savings - New Units** | | | | | | | | | | | | |
| Base Line | 0.6 | $ - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy Star | 0.7 | $ 50.00 | 51 | 0 | 23.0 | 250,000 | 430 | 28.6 | 200,000 | 0.60 | 1.20 | 20,000 |
| | | | | | | | | | | | | |
| **Early Retirement** | | | | | | | | | | | | |
| Typical Dishwasher | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy Star | 0.7 | 500 | 125.9 | 0 | 55.4 | 287,000 | 559 | 69.5 | 229,600 | 0.6888 | 0.98 | 22,960 |

For early retirement, the measure life is 12 years. However, the first three years savings (69.5 weighted all fuels) are based on the old dishwasher (typical) verses the new Energy star dishwasher (assumes old dishwasher would have been used another 3 years) and the remaining 9 years savings (28.6 weighted all fuels) are based on the new energy star dishwasher verses the baseline.

Note: Retirement savings may only be claimed if retirement is program induced.

## ***Method for Calculating Demand Savings***

The demand savings for the summer or winter peak period is calculated by multiplying the annual kWh savings by a summer or winter peak coincidence factor for domestic water heating found in Appendix Table 1.1.3.

## ***Baseline Efficiencies from which savings are calculated***

The baseline efficiencies are the Federal Standard values shown in the table above.

## ***Operating Hours***

Operating hours do not apply since the Federal Standards are written in units of cycles/kWh.

***Incremental Cost***

The Energy Star web site uses $50 as the incremental cost between an Energy Star model and a Federal Standard model.
Source: Survey conducted by APT

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Annual Fossil Fuel savings is shown in table above.

***Non-Electric Benefits - Annual Water Savings***

The annual water savings is shown in the table above.
Source: Energy Star Website

***Notes & References***

www.energystar.gov

***Revision Number***

04

# 5.3.9 REFRIGERATOR

## *Method for Calculating Energy Savings*

Refrigerators qualifying as Energy Star refrigerators must consume 15% less electricity than that required by current Federal Standards. These standards can be found in the Federal Register mentioned above for all types and configurations up to a total refrigerated volume of 30 cubic feet.

| **Refrigerator Savings Assumptions** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Refrigerator Size (Adjusted Volume)** | | | | | | | | | | | | |
| | **10** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **20** | **21** | **22** | **24** | **25** |
| Manual Defrost | 53 | 56 | 58 | 59 | 61 | 63 | 64 | 66 | 69 | 71 | 72 | 76 | 79 |
| Partial Auto Defrost | 53 | 56 | 58 | 59 | 61 | 63 | 64 | 66 | 69 | 71 | 72 | 76 | 79 |
| Top Freezer no ice door | 59 | 63 | 64 | 66 | 68 | 70 | 71 | 73 | 76 | 79 | 80 | 84 | 87 |
| Side Freezer no ice door | 85 | 87 | 88 | 88 | 89 | 90 | 91 | 92 | 94 | 95 | 96 | 98 | 99 |
| Bottom Freezer no ice door | 77 | 79 | 80 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 89 | 90 |
| Top Freezer with ice door | 72 | 76 | 77 | 79 | 81 | 83 | 84 | 87 | 90 | 92 | 94 | 98 | 101 |
| Side Freezer with ice door | 79 | 83 | 84 | 86 | 88 | 90 | 91 | 94 | 97 | 99 | 101 | 105 | 108 |

## *Method for Calculating Demand Savings*

The demand savings during the summer or winter peak period is calculated by multiplying the annual kWh savings by the appropriate peak kW/kWh factor for residential refrigeration found in Appendix Table 1.1.3

## *Baseline Efficiencies from which savings are calculated*

The baseline efficiency is that of a refrigerator which meets the Federal Standard as described above.

For early retirement, the baseline is the rated usage of the existing unit based on AHAM refrigerator data.

## *Compliance Efficiency from which incentives are calculated*

The compliance efficiency is that of a refrigerator which meets the Energy Star standard and uses a minimum of 15% less electricity than a refrigerator meeting the Federal Standard.

## *Operating Hours*

Operating hours are included in the Federal Standards and are not separated from the Federal Standard calculations.

## *Incremental Cost*

The incremental cost of a refrigerator meeting Energy Star standards is estimated to be $75.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

Note 1: Based on Nexus Market Research Evaluation of the 2005 Appliance Retirement Program offered by CL&P and UI.

***Revision Number***

04

# 5.3.10 ROOM AC RETIREMENT

***Description of Measure***

This measure applies to old room air conditioners which are in working condition, but are turned in to a demanufacturing facility where they are properly disassembled, with all materials recycled where possible.

***Method for Calculating Energy Savings***

For early retirement, the measure life is 12 years. However, the first 3 years savings are based on the old air conditioner (assumes old unit would have been used another 3 years) and the remaining 9 years savings are based on the new energy star air conditioner.

The savings are estimated to be 191kWh per year for the first three years and 58 kWh for the remaining 9 years. A realization factor of 20.7% should be applied for the first 3 years and 26.0% for the remaining 9 years.

Note: Retirement savings may only be claimed if retirement is program induced.

Energy Savings and Realization rate base on Impact, Process, and Market study of CT Appliance retirement Program, Nexus Market Research, Inc., December 2005, Table 2.13, page 25

***Method for Calculating Demand Savings***

Demand savings in kW is calculated by multiplying the annual savings in kWh by the summer system peak kW/kWh factor found in Appendix Table1.1.3.

***Baseline Efficiencies from which savings are calculated***

The Federal Standard baseline efficiency is 9.7BTU/W.

***Compliance Efficiency from which incentives are calculated***

The unit retired must be in working condition when retired.

***Operating Hours***

The full load operating hours for CT is assumed to be 500 hours per year.

***Total Cost***

The cost to pick up and demanufacture an AC unit is $65.00 plus any customer incentive.

***Revision Number***

03

## 5.3.11 REFRIGERATOR RETIREMENT

***Description of Measure***

This measure is for the retirement and demanufacturing of refrigerators. Refrigerators are picked up at the customer's premises, and removed to a central facility operated by a contractor where they are disassembled, with all material recycled where practical. The refrigerators are required to be in working order, preferably having been in operation as a second or third refrigerator.

***Method for Calculating Energy Savings***

It is assumed that the refrigerators would continue in daily operation for another 5 years without the retirement program. It is assumed that the refrigerators are not replaced by the owners. The energy savings is calculated as the average consumption for the average refrigerator retired times 5 years. The average consumption is estimated at 1,383 kWh per year. A realization factor of 29.9% should be applied to the savings. The result is 414 kWh/y.

Energy Savings and Realization rate base on Impact, Process, and Market study of CT Appliance retirement Program, Nexus Market Research, Inc., December 2005, Table 2.13, page 25

Note: Retirement savings may only be claimed if retirement is program induced.

***Method for Calculating Demand Savings***

The annual kWh savings is multiplied by the peak kW/kWh factor for summer and winter residential refrigeration found in Appendix Table 1.1.3.

***Baseline Efficiencies from which savings are calculated***

Since the refrigerators are removed from service and not replaced, no baseline efficiency is involved in the savings calculation.

***Compliance Efficiency from which incentives are calculated***

There is no compliance efficiency involved in the savings calculation

***Operating Hours***

Operating hours are included in the annual energy consumption estimated for the refrigerators and are not broken out of the annual estimates of kWh.

***Total Cost***

The current cost to pick up a refrigerator at the customer's home and to demanufacture it is $85 plus any customer incentive.

***Revision Number***

05

## 5.3.12 FREEZER

***Description of Measure***

This measure is for the retirement and demanufacture of working freezers that are generally more than 10 years old. The freezers are picked up at the customer's premises by a contractor, and taken to the contractor's facility where they are demanufactured with materials recycled where possible.

***Method for Calculating Energy Savings***

It is assumed that the freezers would continue in daily operation for another 5 years without the retirement program. It is assumed that the freezers are not replaced by the owners. The energy savings is calculated from the average consumption for the average freezer is estimated at 1,181 kWh/y. After applying a realization rate of 38.1% on a program wide basis the average savings in consumption is assumed to be 450 kWh per year.

Energy Savings and Realization rate base on Impact, Process, and Market study of CT Appliance retirement Program, Nexus Market Research, Inc., December 2005, Table 2.13, page 25

Note: Retirement savings may only be claimed if retirement is program induced.

***Method for Calculating Demand Savings***

The peak demand savings is calculated from the peak kW per kWh factors for residential freezers found in Appendix Table 1.1.3.

***Baseline Efficiencies from which savings are calculated***

Since the freezers are removed from service and not replaced, no baseline efficiency is involved in the savings calculation.

***Compliance Efficiency from which incentives are calculated***

There is no compliance efficiency involved in the savings calculation.

***Operating Hours***

Operating hours are included in the annual energy consumption estimated for the freezers and are not broken out of the annual estimates of kWh.

***Total Cost***

The current cost to pick up a freezer at the customer's home and to demanufacture it is $85 plus any customer incentive.

***Revision Number***

04

# 5.3.13 DEHUMIDIFIER RETIREMENT

***Description of Measure***

This measure applies to old dehumidifiers which are in working condition, but are turned in to a demanufacturing facility where they are properly disassembled, with all materials recycled where possible.

***Method for Calculating Energy Savings***

| Early Retirement | | | |
|---|---|---|---|
| **Dehumidifiers** | **EF** | **Incremental Cost** | **Electric** |
| **Pints/day** | **(L/kWh)** | | **kWh** |
| **Based on 40-pint** | | | |
| Typical dehumidifier | 1.28 | 0 | 1,239.35 |
| ES 1 to 25 | 1.20 | 150 | 643 |
| ES 25 to 35 | 1.40 | 150 | 555 |
| ES 35 to 45 | 1.50 | 150 | 388 |
| ES 45 to 54 | 1.60 | 150 | 252 |
| ES 54 to 75 | 1.60 | 150 | 95 |
| ES 75 to 185 | 2.50 | 150 | 54 |

For early retirement, the measure life is 12 years. However, the first 3 years savings (table above) are based on the old dehumidifier (typical) verses the new Energy Star unit (assumes old unit would have been used another 3 years) and the remaining 9 years of savings (see measure 5.3.14) are based on the new energy star air dehumidifier verses the baseline.

Note: Retirement savings may only be claimed if retirement is program induced.

***Method for Calculating Demand Savings***

Demand savings is calculated by multiplying the expected annual savings in kWh by (1/1900) * (74%) where 1900 represents the expected annual operating hours and (74%) is the estimated coincidence of the operation of each unit with the system peak.

***Baseline Efficiencies from which savings are calculated***

| Conventional | | | **Electric Consumption** | |
|---|---|---|---|---|
| | **EF (L/kWh)** | **L/Day** | **kWh/Day** | **kWh** |
| 1 to 25 | 1.10 | 10.60 | 9.63 | 650 |
| 25 to 35 | 1.35 | 14.19 | 10.51 | 710 |
| 35 to 45 | 1.36 | 18.92 | 13.91 | 939 |
| 45 to 54 | 1.47 | 23.41 | 15.93 | 1,075 |
| 54 to 75 | 1.53 | 30.51 | 19.94 | 1,346 |
| 75 to 185 | 2.38 | 43.89 | 18.44 | 1,245 |

***Operating Hours***

The annual operating hours are estimated to be 67.5 days per year X .66 duty factor = 44.55 hours/year

***Total Cost***

The total cost to pick up a dehumidifier and to demanufacture it is $65.00 plus any customer incentive.

***Revision Number***

06

## 5.3.14 DEHUMIDIFIER

***Description of Measure***

Energy Star Dehumidifier through a negotiated cooperative promotion.

***Method for Calculating Energy Savings***

**Table1: Annual Energy Savings**

| Dehumidifiers | EF | Incremental Cost | Electric |
|---|---|---|---|
| **Pints/day** | **(L/kWh)** | | **kWh** |
| **Savings - New Units** | | | |
| 1 to 25 | 1.20 | 0 | 54 |
| 25 to 35 | 1.40 | 0 | 25 |
| 35 to 45 | 1.50 | 0 | 88 |
| 45 to 54 | 1.60 | 0 | 87 |
| 54 to 75 | 1.80 | 0 | 59 |
| 75 to 185 | 2.50 | 0 | 60 |

Incremental Cost was an estimated average
Ref: Energy star web site

***Method for Calculating Demand Savings***

Demand savings is calculated by multiplying the expected annual savings in kWh (115kWh) by (1/1900) * (74%) where 1900 represents the expected annual operating hours and (74%) is the estimated coincidence of the operation of each unit with the system peak. The demand savings as described above would be 0.03 kW

***Baseline Efficiencies from which savings are calculated***

| Conventional | |
|---|---|
| | **EF (L/kWh)** |
| 1 to 25 | 1.10 |
| 25 to 35 | 1.35 |
| 35 to 45 | 1.36 |
| 45 to 54 | 1.47 |
| 54 to 75 | 1.53 |
| 75 to 185 | 2.38 |

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is the Energy Star efficiency of 1.3L/kWh.

***Operating Hours***

The annual operating hours are estimated to be 67.5 days per year X .66 duty factor = 44.55 hours/year

***Total Cost***

The total cost to pick up a dehumidifier and to demanufacture it is $65.00 plus any customer incentive

***Notes & References***

Savings and baseline efficiency factors are from the energy star website.

***Revision Number***

05

## 5.4.1 REM SAVINGS

***Description of Measure***

Energy Star Home which is certified through a HERS (Home Energy Rating System) rating. Energy Star Homes are limited to single family homes or multi-family homes that are three stories or less. Hi-rise units do not qualify for Energy Star certification and the savings methodology below does not apply to those units.

***Method for Calculating Energy Savings***

The traditional method of qualifying Energy Star Homes is through a HERS rating. The rating involves inputting the key energy features into a computer program (geometry, orientation, thermal performance, mechanical systems, etc.) that will generate a HERS score and other useful information regarding the energy usage of the home. REM/Rate® (REM) is the software that is used in Connecticut (and in most jurisdictions) to generate HERS ratings.

A feature of REM is that it enables the user to define a base home ("user defined reference home", or UDRH) and calculate the savings of an actual home relative to the UDRH. The UDRH is the same size as the "as-built" and utilizes the same type of mechanical systems and fuels. However, the thermal and mechanical efficiencies of the UDRH are set to baseline levels. The current baseline levels were established in 2003 through a baseline evaluation conducted by RLW Analytics Inc. (Note 1). Some of the key variables of the UDRH are listed in the following table.

| | |
|---|---|
| Flat Ceiling U-Value | 0.0384 (approx R-30) |
| Exterior Wall U-Value | 0.07 (approx R-19) |
| Window U-Value | 0.35 |
| Window SHGC | 0.30 |
| Duct Leakage | None Observable |
| Infiltration | 0.34 ACH |
| Cooling | 13 SEER |
| Geothermal | 13 SEER, Fossil Fuel Heat |

The UDRH report generates heating, cooling and water heating consumption for the "as-built" home and the defined "base" home. The difference between those values is the savings. This savings is referred to "REM" savings.

The following table is an example of what a typical UDRH report looks like.

| | **UDRH Consumption** | **As-Built Consumption** | **Savings** |
|---|---|---|---|
| Heating | 40.5 | 34.8 | 5.7 |
| Cooling | 4.5 | 2.3 | 2.2 |
| Water Heating | 20.6 | 17.5 | 3.1 |

Note that the numbers above represent MBtu's. Based on the corresponding fuel for these end-uses, the above numbers can be converted to their respective units of measure (i.e. gallons of oil, Therms of gas, kWh of electricity, etc).

The REM savings above includes the effect of installing a programmable thermostat, so additional savings should not be claimed if one (or more) is programmable thermostat is installed. Also, REM has the ability to incorporate lights and appliances into an "expanded" rating. Connecticut does NOT use the expanded rating. Therefore, the REM savings does not include savings for lights and appliances. These savings (if any) are calculated separately.

Since REM savings is based on a whole building approach (i.e. it includes the effects of upgraded insulation, tighter ducts, increased efficiencies, etc), this savings methodology takes precedence over "code-plus" measures. Savings for homes that have a REM analysis done should be calculated using the UDRH Report; and no additional savings should be claimed based on code-plus measures.

### ***Method for Calculating Demand Savings***

The demand savings is calculated using peak factors found in Table 1.1.3 in the Appendix.

### ***Baseline Efficiencies from which savings are calculated***

An "average" home built in Connecticut as determined by a baseline evaluation. Note that the baseline is NOT a home built to minimum code standards. While many homes fail to meet some aspects of the energy code, their performance overall exceeds minimum code performance substantially and therefore, the baseline exceeds minimum code performance as well.

### ***Compliance Efficiency from which incentives are calculated***

Energy Star

### ***Incremental Cost***

Incremental cost is assumed to be $1.00 per square foot heated living space.

### ***Non-Electric Benefits - Annual Fossil Fuel Savings***

There is fossil fuel savings for homes that utilize fossil fuel for heating and/or water heating. Most homes in the program utilize fossil fuel for heating and water heating, so the UDRH MBtu savings numbers will be converted to the appropriate fossil fuel unit.

### ***Notes & References***

Note 1. *Baseline Evaluation for the Energy Star Home New Construction Program*, January 2002. Prepared for Northeast Utilities and United Illuminating.

### ***Revision Number***

05

# 5.4.4 BLOWER DOOR TEST

***Description of Measure***

Energy savings due to reductions in infiltration that are not already captured through an alternative measures which captures the effects of reduced infiltration. Examples of measures which capture the effects of infiltration are: home rating REM Savings 5.4.1 and BOP Savings 4.4.2, Duct leakage is captured during blower door testing. However, the savings calculations below are based on homes with no ducts, so this measure can be paired with either of the duct sealing measures (5.2.8 & 5.2.9) without fear of double-counting.

***Method for Calculating Energy Savings***

Table 1 – Savings for new homes

| CFM 50 per square foot conditioned space | MBtu Heating Savings per 1000 sq ft | kWh Heating Savings (geothermal) per 1000 sq ft. | KWh Heating Savings (air handler/Fan systems only) per 1000 sq ft. | kWh Cooling Savings per 1000 sq ft |
|---|---|---|---|---|
| 1.00 | 0.0 | 0.0 | 0 | 0 |
| 0.95 | 0.3 | 26 | 3 | 13 |
| 0.90 | 0.7 | 51 | 6 | 26 |
| 0.85 | 1.0 | 77 | 8 | 39 |
| 0.80 | 1.4 | 102 | 11 | 52 |
| 0.75 | 1.7 | 128 | 14 | 65 |
| 0.70 | 2.1 | 154 | 17 | 78 |
| 0.65 | 2.4 | 180 | 19 | 91 |
| 0.60 | 2.8 | 205 | 22 | 104 |
| 0.55 | 3.1 | 231 | 25 | 117 |
| 0.50 | 3.5 | 156 | 28 | 130 |
| 0.45 | 3.8 | 282 | 30 | 143 |
| 0.40 | 4.2 | 308 | 34 | 156 |
| 0.35 | 4.5 | 334 | 36 | 169 |
| 0.30 | 4.9 | 359 | 39 | 182 |

*Blower Door Savings for New Homes (based on 1 CFM at 50 Pa per square foot conditioned floor area.*

Table 2 – Retrofit Savings

| Savings per 100 CFM (at 50 Pa) reduction | | |
|---|---|---|
| **Measure** | **Savings** | **Units** |
| Electric Resistance Heat | 156 | kWh |
| Heat Pump Heating | 78 | kWh |
| Geothermal Heating | 52 | kWh |
| Air Handler (fan) Heating | 6.4 | kWh |
| Fossil Fuel Heating | 0.8 | MBtu |
| Cooling | 45 | kWh |

***Method for Calculating Demand Savings***

The demand savings is calculated using peak factors found in Table 1.1.3 in the Appendix.

***Compliance Efficiency from which incentives are calculated***

Infiltration of less than 1 CFM per square foot conditioned leakage verified with blower door testing.

***Incremental Cost***

25 cents per square foot of conditioned space (estimated)

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

| MBtu Savings (from above) | Gallons Oil | Therms Gas | Gallons Propane |
|---|---|---|---|
| 0.0 | 0.0 | 0.0 | 0.0 |
| 0.1 | 0.9 | 1.3 | 1.5 |
| 0.2 | 1.9 | 2.7 | 2.9 |
| 0.3 | 2.8 | 4.0 | 4.4 |
| 0.4 | 3.9 | 5.3 | 5.9 |
| 0.5 | 4.8 | 6.7 | 7.5 |
| 0.6 | 5.7 | 8.0 | 8.9 |
| 0.7 | 6.7 | 9.3 | 10.4 |
| 0.8 | 7.6 | 10.7 | 11.9 |
| 0.9 | 8.5 | 12.0 | 13.3 |
| 1.0 | 9.5 | 13.3 | 14.8 |

Estimated savings values are taken into account average expected system efficiency of 75%

***Revision Number***

06

## 5.4.5 HIGH PERFORMANCE WALL INSULATION

***Description of Measure***

High performance insulation. The following are examples of high performance insulation. In order to be considered as high performance, the whole wall R-value (including framing) must be better than an R-15 and have proven ability to substantially retard infiltration relative to standard fiberglass insulation. The following are examples of high performance insulation:

Cellulose, 2 x 6 framing
Blown-in fiberglass, 2 x 6 framing
Icynene, 2 x 6 framing
SIPs panels (3.5 inches or better)
Insulated concrete forms
2 x 4 wall (fiberglass cavity) with 1 inch of rigid (R-5) insulation.
Any wall assembly which can be demonstrated to thermally perform as well as any of these options.

Note that thermal mass does NOT equate to R-value. Solid wood walls (log cabins) are NOT considered high performance walls and do NOT qualify (they do not meet the R-value or infiltration requirement).

Since the savings calculation includes the effects of decreased infiltration, homes that qualify for this measure do NOT qualify for any incentive for blower door reduction, nor should savings for both measures be counted. Also, if a home is HERS rated, the UDRH savings takes precedent over the savings presented here and additional wall insulation savings should not be claimed. Homes that meet ENERGY STAR standards or meet the federal tax credit standards should calculate the savings based on measure 5.4.7 and should not claim additional wall insulation savings.

This measure applies to new construction only. For retrofit savings, refer to measure 6.4.13.

***Method for Calculating Energy Savings***

Parallel flow method was used to calculate savings (Note 1) based on a standard 2 x 6 wall with fiberglass.

**Heating Savings** = $(1/R_{existing} - 1/R_{New})$ x Degree Days x 24 x Adjustment x Area + infiltration saving

where: $R_{existing}$ is the effective R-value of the existing wall assumed to be 12
$R_{New}$ is the upgraded effective R-value assumed to be 15
Degree days = 6200 assumed state average
Adjustment = 0.64 ASHRAE adjustment factor (Note 2)
Area = 100 square feet .
Infiltration savings estimate = 50,000 Btu per 100 sq feet.

Note: infiltration savings is backed out for homes that are blower door tested (savings is multiplied by 76% to account for the infiltration component) and measure 5.4.4 is used to calculate the savings from infiltration reduction to account for reduced infiltration.

Annual Btu saving = 208,720 per 100 square feet of wall = 0.209 MBtu for non-blower door tested homes or 0.209 MBtu x 76% = 0.159 MBtu + 5.4.4 Blower Door Savings.

Therefore, Annual Savings (for homes with electric heat):

Electric resistance savings = 61 kWh per 100 square feet
Heat Pump savings = 30.5 kWh per 100 square feet
Fan savings (furnace fan or air handler) is estimated to be 20 kwh per MBtu or 4.2 kwh per 100 square feet.

**Cooling Savings =** estimated at 5 kWh per 100 square feet of wall. 76% of this value is used for blower door tested homes and the savings is supplemented by measure 5.4.4.

***Method for Calculating Demand Savings***

The demand savings is calculated using peak factors found in Table 1.1.3 in the Appendix.

***Incremental Cost***

50 cents per square foot.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

MBtu savings = .28 per 100 square feet.

Therefore,
annual gas savings = 2.8 Therms/year per 100 sq ft.
annual oil savings = 2.0 Gallons/year per 100 sq ft.
annual propane = 3.1Gallons/year per 100 sq ft.

***Notes & References***

Note 1. Joe Swift, Northeast Utilities, 2005.

Note 2. ASHRAE degree-day correction. 1989 ASHRAE Handbook Fundamentals 28.2, Fig 1

***Revision Number***

05

# 5.4.6 HIGH PERFORMANCE CEILING INSULATION

***Description of Measure***

High performance insulation: In order to be considered as high performance ceiling insulation, the whole component R-value (including framing) must be better than an R-35 and have proven ability to substantially retard infiltration relative to standard fiberglass insulation. The following are examples of high performance insulation:

Cellulose
Icynene (spray foam)
SIPs panels (3.5 inches or better)
Spray foam loose fill combination (loose fill fiberglass by itself does NOT qualify)
Hybrid systems (rigid foam with fiberglass)

Any wall ceiling assembly which can be demonstrated to thermally perform as well as any of these options. Thermal mass should not be used to make adjustments to R-values.

Since the savings calculation includes the effects of decreased infiltration, homes that qualify for this measure that are blower door tested should use the blower door results to calculate the savings. Also, if a home is HERS rated, the UDRH savings takes precedent over the savings presented here and additional wall insulation savings should not be claimed. Homes that meet ENERGY STAR standards or meet the federal tax credit standards should calculate the savings based on measure 5.4.7 and should not claim additional ceiling insulation savings.

This measure is for new construction only. For retrofit savings, refer to measure 6.4.12.

***Method for Calculating Energy Savings***

**New Construction** (for new homes, uses fiberglass code-minimum as baseline)

**Heating Savings** = $(1/R_{existing} - 1/R_{New})$ x Degree Days x 24 x Adjustment x Area + infiltration saving

Where: $R_{existing}$ is the effective R-value of the existing ceiling assumed to be 25
$R_{New}$ is the upgraded effective R-value assumed to be 35
Degree days = 6200 assumed state average
Adjustment = 0.64 ASHRAE adjustment factor (Note 2)
Area = 100 square feet .
Infiltration savings estimate = 100,000 Btu per 100 sq feet. **Infiltration savings should be subtracted out if blower door savings is claimed**. Above savings should be multiplied by 52% for homes that are blower door tested, and measure 5.4.4 Blower Door Test should be used to calculate the impact reduced infiltration.

Annual Btu saving = 208,837 per 100 square feet of ceiling = 0.208 MBtu per 100 square feet (or 108,837 MBtu plus 5.4.4. Blower Door savings for homes that are blower door tested).

Therefore, Annual Savings (for homes with electric heat):

Electric resistance savings = 61 kWh per 100 square feet
Heat Pump savings = 30.5 kWh per 100 square feet
Heating Fan (air handler) savings = 4.2 kWh per 100 square feet.

**Cooling Savings** = estimated at 5 kWh per 100 square feet of ceiling. For cooling, the infiltration adjustment factor is assumed to be 80%. Therefore, for homes that are blower door tested, 4 kWh per 100 square feet are used plus savings from 5.4.4 Blower Door Test.

***Method for Calculating Demand Savings***

The demand savings is calculated using peak factors found in Table 1.1.3 in the Appendix.

***Incremental Cost***

50 cents per square foot.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

See above for MBtu fossil fuel savings.

***Notes & References***

Note 1. Joe Swift, Northeast Utilities, 2005.

Note 2. ASHRAE degree-day correction. 1989 ASHRAE Handbook Fundamentals 28.2, Fig 1

***Revision Number***

05

## 5.4.7 HOME QUALIFYING FOR TAX CREDIT

***Description of Measure***

Homes that meet the Energy Star Builder Option Package requirements and homes that meet the Federal Tax Credit criteria of exceeding IEECC by 50%.

***Method for Calculating Energy Savings***

The following table shows heating, cooling and water heating energy savings and summer demand for homes that meet the Builder Option Package (BOP) Energy Star criteria and homes that meet the Federal Tax Credit Criteria. Savings shown is per 1,000 square feet of conditioned space calculated using standard HERS methodology.

| Package | Savings | | | |
|---|---|---|---|---|
| | **Heating (MMbtu)** | **Cooling (kwh)** | **DHW (MMbtu)** | **Summer kw** |
| ENERGY STAR Builder Option Package | 6.8 | 166 | 0.5 | 0.28 |
| 50% IEECC Home (Tax Credit Qualified) | 17.1 | 554 | 1.3 | 0.94 |

***Method for Calculating Demand Savings***

Demand Saving is shown on the table above.

***Baseline Efficiencies from which savings are calculated***

Home built to code standard.

***Incremental Cost***

$1 per square foot conditioned space for Energy Star BOP; $2 per square foot conditioned space for the Tax Credit Home.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

See above.

***Revision Number***

00

## 5.5.1 WATER HEATER THERMOSTAT SETTING

### ***Description of Measure***

This measure is for lowering of the hot water temperature in an electric domestic hot water heater.

### ***Method for Calculating Energy Savings***

Please see the table below: Savings will occur only when the lower temperature of the hot water does not require the use of more hot water. Savings will not occur in an application such as a shower where the user demands a certain water temperature and will increase the hot water flow to make up for the lower temperature. A realization rate of 50 % has been applied to the faucet since savings will result only when the hot water is being wasted, and not when the user requires a certain temperature and increases the water flow to compensate for the reduced temperature.

| **Lower Electric Water Heater Temp from 140 to 125F** | **Faucet** | **Clothes Washer** | **Totals** |
|---|---|---|---|
| **Water Consumption** | | | |
| Best available efficient aerator GPM | 1.5 | | |
| Duration of use, minutes | 0.5 | | |
| No of uses / day | 30 | | |
| Days/year | 260 | | |
| **Gallons of hot water used / year** | **5,850** | **2080** | **7,930** |
| **Consumption / cycle gallons hot water** | | 10 | |
| **Cycles/week** | | 4 | |
| **Energy Savings** | | | |
| **Btu** | | | |
| Temp water to house in degrees F | 55 | 55 | |
| Original hot water temp in degrees F | 140 | 140 | |
| Reset water temp in degrees F | 125 | 120 | |
| Temp savings in degrees F | 15 | 15 | |
| Weight of water pounds/gal | 8.3 | 8.3 | |
| Btu savings /gal | 124.5 | 124.5 | |
| Btu saved /year | 728,325 | 258,960 | |
| MBtu saved/year | 0.728 | 0.259 | |
| **kWh Electricity** | | | |
| kWh/Mbtu | 293 | 293 | |
| **Elect saved/year in kWh** | **213** | **76** | |
| Efficiency of electric hot water | 0.9 | 0.9 | |
| **Total Elect saved/year kWh at water heater** | **237** | **84** | |
| **Apply realization rate of 50% to faucet savings** | **118.5** | **84** | **202.5** |
| **Natural Gas** | | | |
| Gas saved/ year in MBtu | 0.728 | 0.259 | |

**Lower Electric Water Heater Temp from 140 to 125F**

| | Faucet | Clothes Washer | Totals |
|---|---|---|---|
| Efficiency of gas water heater | 0.6 | 0.6 | |
| Gas Saved/year in MBtu at water heater (1,000 Cu ft) | **1.213** | **0.43** | |
| **Apply realization rate of 50% to faucet savings** | **0.61** | **0.43** | **1.04** |
| | | | |
| **No.2 Oil** | | | |
| No 2 Oil, Btu/gal | | | 140,000 |
| Gallons of No. 2 oil saved / year | 5.2 | 1.8 | |
| Efficiency of oil fired heater | 0.5 | 0.5 | |
| **Gallons of No 2 oil saved at heater** | **10.4** | **3.6** | |
| | | | **8.8** |
| **Apply realization rate of 50% to faucet savings** | **5.2** | **3.6** | |

***Method for Calculating Demand Savings***

There is no demand savings associated with this measure.

***Baseline Efficiencies from which savings are calculated***

The base line efficiency is considered to be the 140F water heater outlet temperature.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is considered to be the 125F water heater outlet temperature.

***Operating Hours***

The operating hours are included in the water consumption values in the table.

***Total Cost***

Since this is a low income measure, it is commonly done by a contractor and has a total cost of $5.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

See Method for Calculating Energy Savings.

***Non-Electric Benefits - Annual Water Savings***

See Method for Calculating Energy Savings.

***Revision Number***

05

# 5.5.2 WATER HEATER WRAP

***Description of Measure***

Electric Hot water heaters with fiberglass insulation are wrapped with an insulating blanket to reduce standby heat loss through the skin. This measure is not necessary for newer units which are insulated with foam.

***Method for Calculating Energy Savings***

The reference used for this measure is "Meeting the Challenge: The Prospect of Achieving 30 percent Energy Savings Through the Weatherization Assistance Program" by the Oak Ridge National Laboratory - May 2002.

The home studied in the Northeast had a gas fired water heater, and was not applicable, since only electric water heaters are wrapped in the Low Income programs. The southern home in the study did have an electric water heater. The difference in the actual heating and storage of hot water may be a little different in the South versus the Northeast, but the southern home can still be used as a good approximation.

The temperature of the water entering the heater may be warmer in the South versus the Northeast, especially in the Winter, but this would not affect standby losses which the wrapping seeks to reduce. The other difference is that the heat loss from the tank to the environment may be greater in the Northeast than the South because of the more mild Southern winters and the warmer southern summers. Therefore the Southern house can be used as a good approximation to a house in the Northeast with a possible slight upward bias.

The Oak Ridge study predicted that wrapping a 40 gallon water heater would result in an increase in the energy factor form 0.86 to 0.88 with a resulting savings of 0.20 MBTU. The electric equivalent of 0.20 MBtu is 0.2 X 293 kWh/MBtu = 58.6 kWh. Adjusting upward for a house in Connecticut, the estimated annual savings is approximately 70 kWh.

***Method for Calculating Demand Savings***

The demand saving is calculate by multiplying the annual kWh savings by the summer or winter peak factor for domestic hot water found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

The base line efficiency used is that of a foam-insulated electric water heater with an energy factor of 0.86.

***Compliance Efficiency from which incentives are calculated***

The tank must have fiberglass insulation.

***Operating Hours***

Operating hours are used in the heat loss calculations, but only the result of those calculations is used here.

***Total Cost***

Since this is a low income program, the entire cost is borne by the program. The estimated cost is $16.00 for the material and $8.00 for the labor.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

The reference used for this measure is "Meeting the Challenge: The Prospect of Achieving 30 percent Energy Savings Through the Weatherization Assistance Program" by the Oak Ridge National Laboratory - May 2002.

***Revision Number***

04

# 5.5.3 LOW FLOW SHOWERHEAD

***Description of Measure***

This measure is for the installation of 2.2 GPM low flow showerheads

***Method for Calculating Energy Savings***

The savings are estimated as shown in the table below.

| | | | | | |
|---|---|---|---|---|---|
| **Water Savings = ((Act.GPM - 2.2 GPM) X (min/shr) X (shr /day) X (days/y)) Gal/y** | | | | | |
| Actual shower flow in GPM as found | 3 | 3.5 | 4 | 4.5 | 5 |
| Federal standard for new construction | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Savings in Gal/min | 0.8 | 1.3 | 1.8 | 2.3 | 2.8 |
| Duration of use, minutes | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| No. of showers/day | 2 | 2 | 2 | 2 | 2 |
| Days/year | 365 | 365 | 365 | 365 | 365 |
| Gallons of Water Saved/year | **1,460** | **2,373** | **3,285** | **4,198** | **5,110** |
| | | | | | |
| **Energy Sav =((Water sav X (Temp to shr-temp to htr) X (8.3) / (1,000,000)) Mbtu/y** | | | | | |
| BTU | | | | | |
| Temp water to house in degrees F | 55 | 55 | 55 | 55 | 55 |
| Temperature water to shower in degree F | 105 | 105 | 105 | 105 | 105 |
| Delta temp in degrees F | 50 | 50 | 50 | 50 | 50 |
| Weight of water pounds/gal | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 |
| BTU required/gal | 415 | 415 | 415 | 415 | 415 |
| MBtu saved /year | **0.606** | **0.985** | **1.363** | **1.742** | **2.121** |
| | | | | | |
| **Elect. Sav = ((Sav at shower in Mbtu/y) X (293) / (0.9 assumed efficiency)) kWh/y** | | | | | |
| kWh/Mbtu | 293 | 293 | 293 | 293 | 293 |
| Elect. saved/year in kWh at showerhead | 177.5 | 288.5 | 399.4 | 510.4 | 621.4 |
| Efficiency of electric hot water heater | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Total elect. saved/year kWh at water heater | **197.3** | **320.5** | **443.8** | **567.1** | **690.4** |
| | | | | | |
| **Nat Gas Sav = ((Sav at shr in Mbtu/y) / (0.6 assumed efficiency) / (1000,000))Mbtu/y** | | | | | |
| Gas saved/year in MBTU at showerhead | 0.606 | 0.985 | 1.363 | 1.742 | 2.121 |
| Estimated efficiency of gas water heater | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Gas in MBTU at water heater | **1.010** | **1.640** | **2.270** | **2.900** | **3.530** |
| | | | | | |
| **No. 2 Oil Sav = ((Sav at shr in Mbtu) / (140,000) / (0.5 assumed efficiency)) Gal/y** | | | | | |
| No 2 Oil, BTU/gal | 140,000 | 140,000 | 140,000 | 140,000 | 140,000 |
| Gallons of No. 2 oil saved/year at faucet | 4.33 | 7.04 | 9.74 | 12.44 | 15.15 |
| Estimated efficiency of oil fired hot water heater | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Gallons of No 2 oil saved at water heater | **8.66** | **14.08** | **19.48** | **24.88** | **30.30** |

***Method for Calculating Demand Savings***

There is no demand savings associated with this measure.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the Federal Standard showerhead with a flow rate of 2.5 gpm at 80 psi.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is 2.2gpm

***Operating Hours***

The operating hours can be calculated from the use time in the table above.

***Total Cost***

Since this measure is used in the Low Income Program, there is no cost to the resident. The total cost for material and installation is $8.10.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The equivalent fossil fuel savings for this measure is shown above in MBtu of gas and gallons of No. 2 oil.

***Non-Electric Benefits - Annual Water Savings***

The annual water savings is shown in the table above in gallons/year.

***Revision Number***

06

# 5.5.4 FAUCET AERATOR

## ***Description of Measure***

Replacement of federal standard 2.2 gpm faucet aerators with best available aerators.

## ***Method for Calculating Energy Savings***

The savings are estimated as shown below and are based on US Federal Energy Management Program assumptions.

| | |
|---|---|
| **Faucet Aerators Water and Energy Savings** | |
| | |
| **Water Savings** | |
| Best available efficient aerator GPM | 1.5 |
| Fed Standard for New Construction GPM | 2.2 |
| Savings GPM | 0.7 |
| Duration of use, minutes | 0.5 |
| No of uses/day | 30 |
| Days/year | 260 |
| **Gallons of Water Saved/year** | **2,730** |
| | |
| **Energy Savings** | |
| Temp water to house in degrees F | 55 |
| Water use temp in degrees F | 80 |
| Delta temp In degrees F | 25 |
| Weight of water pounds/gal | 8.3 |
| BTU required/gal | 207.5 |
| BTU saved /year | 566,475 |
| MBTU saved/year | 0.566 |
| | |
| **kWh Electricity** | |
| kWh/MBTU | 293 |
| **Elect saved/year in kWh at faucet** | **166** |
| Efficiency of electric hot water | 0.9 |
| **Total Elect saved/year kWh at water heater** | **184** |
| | |
| **Natural Gas** | |
| Gas saved/ year in MBTU at faucet | 0.566 |
| Efficiency of gas water heater | 0.6 |
| Gas Saved/year in MBTU at water heater (1,000 Cu ft) | **0.944** |
| | |
| **No.2 Oil** | |
| No 2 Oil, BTU/gal | 140,000 |
| Gallons of No 2 oil saved/year at faucet | **4.046** |
| Efficiency of oil fired heater | 0.5 |
| **Gallons of No 2 oil saved at heater** | **8.0925** |

***Method for Calculating Demand Savings***

There is no demand savings associated with this measure.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the flow rate of an aerator meeting the federal standard of 2.2 gpm.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is 1.5 gpm.

***Operating Hours***

The operating hours assumed are 0.5 minutes/use X 30 uses/day X 260 days/year/60 minutes/hour = 65 hours/year.

***Total Cost***

The total installed cost in the Low Income program is $3.50

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The annual expected non-electric benefits are shown in shown in " Method for Calculating Energy Savings."

***Non-Electric Benefits - Annual Water Savings***

The annual expected water savings is shown in shown in " Method for Calculating Energy Savings."

***Notes & References***

The DOE web site www.eere.energy.gov/femp/technologies/eep_faucets.cfm was used as a reference for this measure.

***Revision Number***

04

## 5.5.5 INSTALL CEILING INSULATION

***Description of Measure***

Installation of ceiling insulation in a residential living unit. The type of insulation installed is assumed to be either loose fill or batt-type insulation. Insulation must be installed between conditioned area and ambient (attic or outside) space. Insulation that is installed between two living spaces (i.e. between floors on a two family unit) does not qualify.

***Method for Calculating Energy Savings***

A parallel flow analysis was conducted (Note 1) and the following charts were generated. The R-value refers to the rated R-value of the insulation. The effective ceiling R-value and heat transfer was calculated to generate these charts. Note that the savings is based on 100 square feet of ceiling area.

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 1,390 | 1,405 | 1,435 | 1,445 | 1,454 | 1,467 | 1,476 |
| **3** | 424 | 439 | 469 | 479 | 488 | 501 | 510 |
| **6** | 214 | 229 | 259 | 269 | 277 | 290 | 300 |
| **9** | 122 | 136 | 167 | 177 | 185 | 198 | 208 |
| **12** | 70 | 85 | 115 | 125 | 134 | 147 | 156 |
| **15** | 37 | 52 | 82 | 92 | 101 | 114 | 123 |
| **19** | | 15 | 45 | 55 | 64 | 77 | 86 |
| **21** | | | 30 | 41 | 49 | 62 | 71 |
| **27** | | | | 10 | 19 | 32 | 41 |

Annual kWh Savings for Electric Resistance Heat (per 100 sq. ft.)

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 695 | 702 | 718 | 723 | 727 | 733 | 738 |
| **3** | 212 | 219 | 235 | 240 | 244 | 250 | 255 |
| **6** | 107 | 114 | 129 | 135 | 139 | 145 | 150 |
| **9** | 61 | 68 | 83 | 88 | 93 | 99 | 104 |
| **12** | 35 | 42 | 57 | 63 | 67 | 73 | 78 |
| **15** | 18 | 26 | 41 | 46 | 50 | 57 | 61 |
| **19** | | 7.47 | 23 | 28 | 32 | 38 | 43 |
| **21** | | | 15 | 20 | 24 | 31 | 36 |
| **27** | | | | 5 | 9 | 16 | 21 |

Annual kWh Savings for Electric Heat Pump (per 100 sq. ft.)

For example, suppose a house with electric resistance heat currently has 2 inches (assumed R-6) insulation in the attic. Insulation is installed to bring the total R-value up to R-30. The savings would be calculated

by locating the R-6 on the left-hand column (pre-existing condition) and following across the row to R-30 (Total Post-installed R-value). For electric heat, the savings would be 269 kWh per 100 square feet of ceiling area.
In cases where the exact R-value (either pre or post) falls between the values on these tables, linear extrapolation can be used to approximate the savings.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.
Cooling savings is not defined for this measure.

***Total Cost***

Actual cost or $1 per square foot as a default.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The following charts can be used to calculate fossil fuel savings for ceiling insulation. These charts are similar in nature to the charts above.

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 45.2 | 45.7 | 46.6 | 47.0 | 47.3 | 47.7 | 48.0 |
| **3** | 13.8 | 14.3 | 15.2 | 15.6 | 15.9 | 16.3 | 16.6 |
| **6** | 6.9 | 7.4 | 8.4 | 8.7 | 9.0 | 9.4 | 9.7 |
| **9** | 4.0 | 4.4 | 5.4 | 5.8 | 6.0 | 6.4 | 6.8 |
| **12** | 2.3 | 2.8 | 3.7 | 4.1 | 4.3 | 4.8 | 5.1 |
| **15** | 1.2 | 1.7 | 2.7 | 3.0 | 3.3 | 3.7 | 4.0 |
| **19** | | 0.5 | 1.5 | 1.8 | 2.1 | 2.5 | 2.8 |
| **21** | | | 1.0 | 1.3 | 1.6 | 2.0 | 2.3 |
| **27** | | | | 0.3 | 0.6 | 1.0 | 1.3 |

Annual Gallons of Oil Saved (per 100 sq. ft.)

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 63.3 | 63.9 | 65.3 | 65.8 | 66.2 | 66.7 | 67.2 |
| **3** | 19.3 | 20.0 | 21.3 | 21.8 | 22.2 | 22.8 | 23.2 |
| **6** | 9.7 | 10.4 | 11.8 | 12.2 | 12.6 | 13.2 | 13.6 |
| **9** | 5.5 | 6.2 | 7.6 | 8.1 | 8.4 | 9.0 | 9.5 |
| **12** | 3.2 | 3.9 | 5.2 | 5.7 | 6.1 | 6.7 | 7.1 |
| **15** | 1.7 | 2.4 | 3.7 | 4.2 | 4.6 | 5.2 | 5.6 |
| **19** | | 0.7 | 2.1 | 2.5 | 2.9 | 3.5 | 3.9 |
| **21** | | | 1.4 | 1.8 | 2.2 | 2.8 | 3.2 |
| **27** | | | | 0.5 | 0.9 | 1.4 | 1.9 |

Annual Therms of Gas Saved (per 100 sq. ft.)

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 70.3 | 71.0 | 72.6 | 73.1 | 73.5 | 74.2 | 74.6 |
| **3** | 21.4 | 22.2 | 23.7 | 24.2 | 24.7 | 25.3 | 25.8 |
| **6** | 10.8 | 11.6 | 13.1 | 13.6 | 14.0 | 14.7 | 15.2 |
| **9** | 6.1 | 6.9 | 8.4 | 8.9 | 9.4 | 10.0 | 10.5 |
| **12** | 3.5 | 4.3 | 5.8 | 6.3 | 6.8 | 7.4 | 7.9 |
| **15** | 1.9 | 2.6 | 4.1 | 4.7 | 5.1 | 5.7 | 6.2 |
| **19** | | 0.8 | 2.3 | 2.8 | 3.2 | 3.9 | 4.4 |
| **21** | | | 1.5 | 2.0 | 2.5 | 3.1 | 3.6 |
| **27** | | | | 0.5 | 0.9 | 1.6 | 2.1 |

Annual Gallons of Propane Saved (per 100 sq. ft.)

***<u>Notes & References</u>***

Note 1. Joe Swift, Northeast Utilities, 2002. Reviewed and updated in April, 2005.

***<u>Revision Number</u>***

02

# 5.5.6 INSTALL WALL INSULATION

***Description of Measure***

Insulation installed (either bat or blown-in) in a wall. Assuming that there is no insulation installed previously.

***Method for Calculating Energy Savings***

Parallel flow method was used to calculate savings (Note 1) based on a typical 2 x 4 wall.
Savings is based on 100 square feet of wall area (net of window and doors).

**Savings** = $(1/R_{existing} - 1/R_{New})$ x Degree Days x 24 x Adjustment x Area

where: $R_{existing}$ is the effective R-value of the existing wall assumed to be 3
$R_{New}$ is the upgraded effective R-value assumed to be 10
Degree days = 6200 assumed state average
Adjustment = 0.64 ASHRAE adjustment factor (note 2)
Area = 100 square feet .

Annual Btu conductive saving = 2,220,000

Therefore, Annual Savings (for homes with electric heat):
Electric resistance savings = 651 kWh
Heat Pump savings = 326 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3. Summer demand savings is zero.

***Total Cost***

Actual cost or $0.75 per square foot as default.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Annual fossil fuel savings = MBtu savings / system efficiency

where: MBtu savings = 2.22
75% is the assumed system efficiency including distribution loss.

Therefore,
annual gas savings = 22.2 Therms/year (for gas heated homes)
annual oil savings = 15.9 Gallons/year (for oil heated homes)
annual propane = 24.7 Gallons/year (for propane heated homes)

***Notes & References***

Note 1. Joe Swift, Northeast Utilities, 2002. Reviewed and updated in April, 2005.

Note 2. ASHRAE degree-day correction. 1989 ASHRAE Handbook Fundamentals 28.2, Fig 1

***Revision Number***

03

# LOW INCOME

# 6.1.1 CFL LIGHT BULB

***Description of Measure***

A direct installed screw-based CFL bulb. Savings does not apply to bulbs that are placed in closets or non-living spaces.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000 (Note 1).

Where:

Δ Watts = 2.4 x CFL wattage (a 3.4 wattage conversion factor).
Hours = 2.6 Hours per day
365 = days per year

For example, the annual savings for a 20 watt CFL:

Annual kWh = 2.4 x 20 watts x 2.6 hours/day x 365 days / 1000 = 45.5 kWh

Note that actual bulb wattage should be used to calculate energy savings – using a default average could lead to a large margin of error. The following chart can be used to calculate the savings for various size bulbs:

| CFL Bulb Wattage | Annual kWh Savings | CFL Bulb Wattage | Annual kWh Savings |
|---|---|---|---|
| 7 | 15.9 | 19 | 43.3 |
| 8 | 18.2 | 20 | 45.6 |
| 9 | 20.5 | 21 | 47.8 |
| 10 | 22.8 | 22 | 50.1 |
| 11 | 25.1 | 23 | 52.4 |
| 12 | 27.3 | 24 | 54.7 |
| 13 | 29.6 | 25 | 56.9 |
| 14 | 31.9 | 26 | 59.2 |
| 15 | 34.2 | 27 | 61.5 |
| 16 | 36.4 | 28 | 63.8 |
| 17 | 38.7 | 29 | 66.1 |
| 18 | 41.0 | 30 | 68.3 |

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting as shown in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Baseline is assumed to be an incandescent light source with a wattage which is 3.4 times higher than the wattage of the CFL bulb. For instance, it's assumed that a 75 Watt incandescent is "equivalent" to a 22 Watt CFL (22 x 3.4 = 75). For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star CFL Bulb.

***Operating Hours***

2.6 Hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$3.00 for spirals, $8.00 for globes, and $12.00 for circleline bulbs.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$4.00 per bulb one time benefit. Estimate based on current cost of incandescent bulbs that would be used in place of one CFL.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

04

## 6.1.2 INDOOR FIXTURE

***Description of Measure***

An Energy Star indoor hardwired fluorescent fixture with pin based bulbs. Fixtures with screw-based (CFL) bulbs are treated as CFL bulbs for savings calculations.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:
Δ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day (Note 1)
365 = days per year

For example, the annual savings for a 25 watt fixture:
Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent fixture with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star hard-wired fixture with equivalent lumen output.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$14.00 (one-time benefit per fixture). Estimate based on added cost of using incandescent bulbs over the life of the measure.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

02

# 6.1.3 OUTDOOR FIXTURE

***Description of Measure***

An Energy Star hardwired outdoor fluorescent fixture with pin based bulbs. Fixtures with screw-based (CFL) bulbs are treated as CFL bulbs for savings calculations.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:

Δ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day (Note 1)
365 = days per year

For example, the annual savings for a 25 watt fixture:

Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent fixture with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way CFL bulbs, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star hard-wired fixture with equivalent lumen output.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$14.00 (one-time benefit per fixture). Estimate based on added cost of using incandescent bulbs over the life of the measure.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

02

# 6.1.4 PORTABLE LAMP

***Description of Measure***

An Energy Star portable (plug type) light fixture with pin-based bulbs (i.e. table lamp, desk lamp, etc.). Torchieres are not included here; rather they are handled as a separate measure.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:

Δ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day (Note 1)
365 = days per year

For example, the annual savings for a 25 watt fixture:

Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent portable fixture with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way products, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star lamp with equivalent lumen output.

***Operating Hours***

3.2 hours per day from RLW 2003 Lighting Evaluation (Note 1).

***Incremental Cost***

$10

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$6.00 (one-time benefit per fixture). Estimate based on added cost of using incandescent bulbs over the life of the measure.

***Notes & References***

Note 1. *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***Revision Number***

02

## 6.1.5 TORCHIERE

***Description of Measure***

Energy Star torchiere.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:
Δ Watts = 2.4 x fixture wattage (a 3.4 wattage conversion factor).
Hours = 3.2 Hours per day (Note 1)
365 = days per year

For example, the annual savings for a 25 watt fixture:
Annual kWh = 2.4 x 25 watts x 3.2 hours/day x 365 days / 1000 = 70.1 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential lighting found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Incandescent or halogen torchiere with a wattage equal to 3.4 times the wattage of the efficient fluorescent fixture. For dimmable or three-way products, assume the highest wattage/setting when calculating the baseline equivalent.

***Compliance Efficiency from which incentives are calculated***

Energy Star torchiere with equivalent lumen output.

***Operating Hours***

3.2 hours per day.

***Incremental Cost***

$10

***<u>Non-Electric Benefits - Annual O&M Cost Adjustments</u>***

$5.00 (one-time benefit per fixture). Estimate based on increased cost of incandescent bulbs that would be used in the baseline case.

***<u>Notes & References</u>***

Note 1. Savings assumptions from: *Northeast Utilities and United Illuminating Retail/Point of Purchase Lighting Program Impact Evaluation*, RLW Analytics, April 2003.

***<u>Revision Number</u>***

02

## 6.1.6 SECURITY

***Description of Measure***

Energy Efficient outdoor security lighting. The difference between "security lighting" and "outdoor lighting" (6.1.3) is that security lighting is controlled to operate throughout the night. Motion controlled lighting or lighting which only operates sporadically is not covered by this definition. Note that when necessary, a lighting measure can be treated as a custom measure.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Where:

Δ Watts = 2.5 x fixture wattage (a 3.5 equivalent wattage conversion factor).
Hours = 12 hours per day (Note 1)
365 = days per year

For example, the annual savings for a 13 watt security fixture:

Annual kWh = 2.5 x 13 watts x 12 hours/day x 365 days / 1000 = 142 kWh

| Security Light (overnight use) Light Savings | | |
|---|---|---|
| **Fixture Wattage** | **Wattage Equivalent** | **Annual kWh Savings** |
| 9.0 | 31.5 | 99 |
| 13.0 | 45.5 | 142 |
| 17.0 | 59.5 | 186 |
| 20.0 | 70.0 | 219 |
| 23.0 | 80.5 | 252 |
| 27.0 | 94.5 | 296 |
| 30.0 | 105.0 | 329 |
| 39.0 | 136.5 | 427 |

***Method for Calculating Demand Savings***

Summer and Winter demand savings can be calculated by using coincidence factors.

Δ Watts = 2.5 x fixture wattage
Summer coincidence factor: 0%
Winter coincidence factor: 90%

These coincidence factors are estimates (note 1) for this type of lighting. Note that peak factors should not be used to calculate demand savings with this measure since its load shape is not typical of this end-use (lighting).

***Baseline Efficiencies from which savings are calculated***

Incandescent fixture with a wattage equal to 3.5 times the wattage of the efficient fluorescent fixture and identical usage patterns.

***Compliance Efficiency from which incentives are calculated***

Energy Star hard-wired fixture with equivalent lumen output and usage pattern.

***Operating Hours***

12 hours per day (overnight).

***Incremental Cost***

$10.

***Non-Electric Benefits - Annual O&M Cost Adjustments***

$14.00 (one-time benefit per fixture). Estimate based on cost of incandescent bulbs that would be used.

***Notes & References***

Note 1. Northeast Utilities estimate, Joe Swift, April 2005.

***Revision Number***

02

# 6.1.7 LIGHTING CUSTOM

***Description of Measure***

A custom project is defined as a project for which accurate savings can not be determined through the existing defined measures. In order for a lighting project to be considered as a "custom lighting" measure, there must be very strong and documented evidence that the current savings algorithms are clearly not appropriate to use. Keep in mind that our current savings assumptions are based on average values derived from a wide range of sample points. Therefore, a lighting measure should not be considered custom simply because the expected savings does not e*xactly* match the defined savings. The fact is that most lighting projects if evaluated on an individual basis would not match the calculated savings exactly, but when looked at collectively, the savings results should be reasonably accurate. Instead, a lighting project should be custom if it clearly exhibits outlier type behavior which would clearly make the existing savings algorithms inappropriate to use and that the existing savings assumptions would produce an error of unacceptable magnitude. Obviously, this involves some level of judgment, and some consideration should be placed on the size of the project and the expected magnitude of the change in savings before a project is defined as custom.

For instance, a large lighting project involves replacing hallway lights in a large multi-unit complex that are on 24 hours per day. Our current assumption for indoor lighting is 3.2 hours per day, but it is known that the sample that this number was based on only included main living areas and did not include common areas. Therefore, it would be appropriate to calculate the savings based on the known (actual) parameters. On the other hand, a single light bulb installed in an outdoor fixture which is kept on overnight by use of a timer would not be considered a custom lighting project even though it's daily hours of use greatly exceed the "average value" that we use in our planning assumptions because presumably this type of usage (bulbs used in outdoor fixtures) would already be reflected in the average values that we use to calculate savings.

For custom lighting measures, the energy and demand savings should be documented by a third party and reviewed by a staff person.

***Method for Calculating Energy Savings***

Annual Energy Savings = Δ Watts x Hours x 365/1000

Δ Watts = the difference between the baseline wattage and final wattage.
Hours = daily hours of use

Both of these variables (and any other factors used to determine energy savings) should be documented.

***Method for Calculating Demand Savings***

Summer Demand Savings = Δ Watts x Summer Coincident factor
Winter Demand Savings = Δ Watts x Winter Coincident factor

To be determined on site and documented.

The coincidence factor for lighting, in the appropriate season (summer or winter), should be obtained by referring to Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

The previous (to program intervention) light source.

***Compliance Efficiency from which incentives are calculated***

The installed (as a result of the program) light source.

***Operating Hours***

Measured on site.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

02

## 6.2.1 DUCT INSULATION

***Description of Measure***

Insulation installed on heating ducts in unconditioned space (either attic or unconditioned basement).

***Method for Calculating Energy Savings***

Engineering estimates (Note 1) were made based on expected operating conditions of residential mechanical systems in this climate. There are four different scenarios modeled: (1) supply duct located in unconditioned basement, (2) return ducts located in unconditioned basement, (3) supply ducts located in the (unheated) attic and, (4) return ducts located in the (unheated) attic. Heating and cooling (for homes with central cooling) savings are presented here:

Annual Energy Savings

| | Heating (MBtu) | kWh (Cooling) |
|---|---|---|
| Supply Basement | 5.3 | 76 |
| Return Basement | 1.0 | 38 |
| Supply Attic | 10.1 | 266 |
| Return Attic | 2.3 | 152 |
| Average Savings (all) | **4.7** | **132.9** |

*Expected Annual savings per 100 square feet of duct that is insulated. Note that the cooling savings is only for homes with central air that use the same duct system.*

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for winter heating and summer cooling found in Appendix Table 1.1.3.

***Baseline Efficiencies from which savings are calculated***

Ducts without insulation.

***Compliance Efficiency from which incentives are calculated***

Ducts insulated to R-6 or better. Duct insulation should not be compressed so that it achieves its rated R-value.

***Total Cost***

Actual cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The heating savings (above) can be converted to appropriate fossil fuel units of measure:

Annual Energy Savings

| | Heating (MBtu) | Gallons Oil | Therms Gas | Gallons Propane |
|---|---|---|---|---|
| Supply Basement | 5.3 | 50.1 | 70.1 | 77.9 |
| Return Basement | 1.0 | 9.3 | 13.2 | 14.7 |
| Supply Attic | 10.1 | 96.7 | 134.8 | 149.7 |
| Return Attic | 2.3 | 21.9 | 30.7 | 34.1 |
| Average Savings (all) | **4.7** | **44.5** | **62.2** | **69.1** |

*Expected Annual savings per 100 square feet of duct that is insulated. Estimated savings values are take into account average expected system efficiency of 75%.*

***Notes & References***

Note 1: Analysis by Joe Swift, Northeast Utilities, 2005.

***Revision Number***

03

# 6.2.2 DUCT SEALING

***Description of Measure***

This measure applies to the savings that is achieved when duct leakage to the outside is reduced. "Outside" duct leakage refers to leakage into unconditioned space such as leakage into unconditioned basements or into unheated attics. Reduction of leakage into conditioned space does not result in energy savings. Testing is based on RESNET test procedures.

***Method for Calculating Energy Savings***

C) apply to Energy Star Homes. For those homes, savings should be calculated using the UDRH (see 5.4.1 REM Savings).

| | Savings per 1000 Square feet Conditioned Space | | | |
|---|---|---|---|---|
| **Duct Blaster Results** (outside leakage per 100 sq feet conditioned space at 25 Pa) | Heating (MBtu) | Geothermal kWh Savings | Heating (kWh Fan Savings) | kWh (Cooling) |
| 8 | 3.1 | 227 | 25 | 101 |
| 7 | 3.9 | 286 | 31 | 127 |
| 6 | 4.7 | 344 | 38 | 152 |
| 5 | 5.5 | 403 | 44 | 177 |
| 4 | 6.3 | 461 | 50 | 203 |
| 3 | 7.0 | 513 | 56 | 228 |
| 2 | 7.8 | 571 | 62 | 253 |
| 1 | 8.6 | 630 | 69 | 279 |
| 0 | 9.4 | 689 | 75 | 304 |

B) **Retrofit**

Savings for existing ducts that are sealed. Savings must be verified by measuring outside duct leakage at 25 Pascals using standard duct blaster testing procedures.

**Duct Blaster Savings at 25 Pa**

| | **Heating (MBtu)** | Heating (Resistance) | Heating (Heat Pumps) | Heating (Geothermal) | kWh Fan Heating Savings | **kWh (Cooling)** |
|---|---|---|---|---|---|---|
| Average Basement Leakage | 5.2 | 1,523 | 762 | 507 | 44 | 159 |
| Average Attic Leakage | 8.1 | 2,373 | 1,187 | 791 | 65 | 234 |
| Average (basement and attic) | 6.7 | 1,948 | 974 | 649 | 55 | 197 |

Savings for 100 CFM at 25 Pa duct leakage reduction

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for winter heating ans summer cooling found in Appendix Table 1.1.3.

***Baseline Efficiencies from which savings are calculated***

Measured results before ducts are sealed.

***Compliance Efficiency from which incentives are calculated***

Duct sealed to reduce outside leakage. Duct sealing improvements verified through a duct blaster test at 25 Pa.

***Total Cost***

Actual Cost

***Non-Electric Benefits - Annual Fossil Fuel Savings***

**B) New Construction:**

The heating savings (above) can be converted to appropriate fossil fuel units of measure

| | Savings per 1000 Square feet Conditioned Space | | | |
|---|---|---|---|---|
| **Duct Blaster Results** (outside leakage per 1000 sq feet conditioned space at 25 Pa) | Heating (MBtu) | Gallons Oil | Therms Gas | Gallons Propane |
| 8 | 3.1 | 29.8 | 41.7 | 46.3 |
| 7 | 3.9 | 37.2 | 52.2 | 57.9 |
| 6 | 4.7 | 44.7 | 62.5 | 69.4 |
| 5 | 5.5 | 52.2 | 73.0 | 81.1 |
| 4 | 6.3 | 59.6 | 83.3 | 92.7 |
| 3 | 7.0 | 67.1 | 93.9 | 104.3 |
| 2 | 7.8 | 74.5 | 104.3 | 115.8 |
| 1 | 8.6 | 81.9 | 114.7 | 127.5 |
| 0 | 9.4 | 89.4 | 125.1 | 139.0 |

*Estimated savings values are take into account average expected system efficiency of 75%.*
In addition, there may be some non-electric benefits due to better comfort and small system size. However, due to their indeterminate nature, it is difficult to rigorously quantify their value with reasonable certainty.

**D) Retrofit**

**Duct Blaster Savings at 25 Pa**

| | **Heating (MBtu)** | Gallons Oil | Therms Gas | Gallons Propane |
|---|---|---|---|---|
| Average Basement Leakage | 5.2 | 50.0 | 70.0 | 77.8 |
| Average Attic Leakage | 8.1 | 76.9 | 107.6 | 119.6 |
| Average (basement and attic) | 6.7 | 63.5 | 88.9 | 98.7 |
| Savings for 100 CFM at 25 Pa duct leakage reduction | | | | |

*Estimated savings values are take into account average expected system efficiency of 75%.*

***Revision Number***

07

# 6.2.3 PIPE INSULATION

***Description of Measure***

Pipe insulation installed on hot water pipes in unconditioned basements.

***Method for Calculating Energy Savings***

Savings for hot water pipes (from an electric resistance source), annual savings is estimated at based on pipe size in table below. The savings values are for 10 linear of hot pipe in unconditioned space.

| Pipe Insulation Annual Electrical Savings | |
|---|---|
| Pipe Diameter (inches) | Savings (kWh) |
| 0.50 | 55 |
| 0.75 | 72 |
| 1.00 | 90 |
| 1.25 | 107 |
| 1.50 | 122 |

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential water heating found in Appendix Table 1.1.3

***Total Cost***

Actual cost OR $10 ($1 per foot) assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

There is fossil fuel savings for hot pipes with a fossil fuel source. Savings values by diameter for 10 linear feet of insulation are presented in the following table:

| Pipe Insulation Annual Fossil Fuel Savings | | | |
|---|---|---|---|
| Pipe Diameter (inches) | Oil (Gallons) | Gas (therms) | Propane (Gallons) |
| 0.50 | 1.7 | 1.2 | 1.3 |
| 0.75 | 2.2 | 1.6 | 1.7 |
| 1.00 | 2.7 | 2.0 | 2.2 |
| 1.25 | 3.3 | 2.3 | 2.6 |
| 1.50 | 3.7 | 2.7 | 3.0 |

*Annual savings per 10 linear feet of hot pipe.*

***Notes & References***

Savings calculation by Joe Swift, Northeast Utilities, 2003 and updated in 2005.

***Revision Number***

03

## 6.2.6 HEATING SYSTEM CUSTOM

***Description of Measure***

Replacement of an old inefficient HVAC system (or component) such as a fossil-fuel furnace, boiler, heat pump or air conditioner (window, sleeve or central).

***Method for Calculating Energy Savings***

This is a custom measure, therefore savings (Note 1) is estimated based on actual before and after conditions. Savings estimates should be documented and reviewed by program staff. In situations where actual savings estimates can not be made, default savings values are also presented.
Since this is an early retirement measure, savings is a step function based on the savings from the removal of the old equipment plus the savings from installing an efficient piece of new equipment.

Annual savings per ton is calculated as follows:

$$Cooling\_savings = \left( \frac{BTU}{old\_SEER} - \frac{BTU}{new\_SEER} \right) \frac{500}{1000} \text{ kWh}$$

The following table gives the default annual savings in kWh for central air cooling system replacement per Ton of system capacity. One Ton = 12,000 Btu/h.

| | | <<<<<< Old Existing Equipment SEER >>>>>> | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | 9.5 | 10.0 |
| << New Equipment SEER >> | 13.0 | 395.60 | 338.46 | 288.46 | 244.34 | 205.13 | 170.04 | 138.46 |
| | 13.5 | 412.70 | 355.56 | 305.56 | 261.44 | 222.22 | 187.13 | 155.56 |
| | 14.0 | 428.57 | 371.43 | 321.43 | 277.31 | 238.10 | 203.01 | 171.43 |
| | 14.5 | 443.35 | 386.21 | 336.21 | 292.09 | 252.87 | 217.79 | 186.21 |
| | 15.0 | 457.14 | 400.00 | 350.00 | 305.88 | 266.67 | 231.58 | 200.00 |
| | 15.5 | 470.05 | 412.90 | 362.90 | 318.79 | 279.57 | 244.48 | 212.90 |
| | 16.0 | 482.14 | 425.00 | 375.00 | 330.88 | 291.67 | 256.58 | 225.00 |

The following table gives the default annual savings in kWh for an air source heat pump replacement per Ton of system capacity. One Ton = 12,000 Btu/h.

$$Heating\_savings = \left( \frac{BTU}{old\_HSPF} - \frac{BTU}{new\_HSPF} \right) \frac{1500}{1000} \text{ kWh}$$

| | | <<<<<<<< Old Existing Equipment HSPF >>>>>>>> | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **5.0** | **5.2** | **5.4** | **5.6** | **5.8** | **6.0** | **6.2** | **6.4** | **6.6** | **6.8** | **7.0** |
| **New Equipment HSPF** | **8.0** | 1350.0 | 1211.5 | 1083.3 | 964.3 | 853.4 | 750.0 | 653.2 | 562.5 | 477.3 | 397.1 | 321.4 |
| | **8.2** | 1404.9 | 1266.4 | 1138.2 | 1019.2 | 908.3 | 804.9 | 708.1 | 617.4 | 532.2 | 451.9 | 376.3 |
| | **8.4** | 1457.1 | 1318.7 | 1190.5 | 1071.4 | 960.6 | 857.1 | 760.4 | 669.6 | 584.4 | 504.2 | 428.6 |
| | **8.6** | 1507.0 | 1368.5 | 1240.3 | 1121.3 | 1010.4 | 907.0 | 810.2 | 719.5 | 634.2 | 554.0 | 478.4 |
| | **8.8** | 1554.5 | 1416.1 | 1287.9 | 1168.8 | 1058.0 | 954.5 | 857.8 | 767.0 | 681.8 | 601.6 | 526.0 |
| | **9.0** | 1600.0 | 1461.5 | 1333.3 | 1214.3 | 1103.4 | 1000.0 | 903.2 | 812.5 | 727.3 | 647.1 | 571.4 |

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating and summer cooling found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

Existing mechanical system or component which meets the following criteria:

1) The existing equipment is being used as the primary source of heating and/or cooling.

2) The existing equipment is in good operating condition and can be expected to be in use in the same location for at least 5 more years if not for program intervention. The inverse of this holds true also: the existing equipment is being replaced because of program intervention and would not have been replaced at this time without intervention or influence from the program.

3) The new unit is sufficiently more efficient to insure that the savings will justify the cost, that the benefit-cost test will be greater than 1, and the measure passes any other applicable benefit/cost screening.

***Compliance Efficiency from which incentives are calculated***

Newly installed system meeting Energy Star or other appropriate high performance efficiency standard.

***Operating Hours***

Assumed to be 1500 for heating and 500 per year for cooling.

***Total Cost***

Actual Cost (preferable) or -

- $3,000 as a default for heating systems or central air/heat pump systems

Note that since this is an early retirement measure, adjustments are made to the cost within the program screening model to account for the deferral of future replacements.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Default savings estimates for fossil fuel are presented below.

Fossil fuel savings for Boiler:

| Input (existing size) Assumed to be 100,000Btu/h | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Savings (MBtu) for furnaces or boilers with tankless coils** | | | | | | | |
| | **New** | **80%** | **82%** | **84%** | **86%** | **88%** | **90%** | **92%** | **92%** |
| **Existing** | **50%** | 52.7 | 54.8 | 56.8 | 58.8 | 60.6 | 62.4 | 64.1 | 64.1 |
| | **55%** | 39.9 | 42.0 | 44.1 | 46.0 | 47.9 | 49.6 | 51.3 | 51.3 |
| | **60%** | 29.3 | 31.4 | 33.4 | 35.4 | 37.2 | 39.0 | 40.7 | 40.7 |
| | **65%** | 20.3 | 22.4 | 24.4 | 26.4 | 28.2 | 30.0 | 31.7 | 31.7 |
| | **70%** | 12.5 | 14.7 | 16.7 | 18.7 | 20.5 | 22.3 | 24.0 | 24.0 |

***Notes & References***

Savings was estimated by Joe Swift, Northeast Utilities, 2006

***Revision Number***

04

# 6.2.7 AC REPLACE

***Description of Measure***

This measure is for the replacement of Room AC units in Low Income households in conjunction with the installation of other low income program measures. The old units are demanufactured to prevent their use in the secondary market.

***Method for Calculating Energy Savings***

The life of the unit is assumed to be as specified in Table 1.4 (If the unit was not turned in it is assumed that it would operate for another 4 years. The savings is the difference in consumption between the new Energy Star unit and the old unit for each of the first four years. The energy savings is the difference between an Energy Star unit and a Federal Standard unit for the remaining years of the measure life.

**For the first 4 years:**
Annual kWh Savings = 500 hours * BTU/h Rating * (1/Actual EER-1/Energy Star EER)/1000W/ kW

**For remaining years of measure life**
Annual kWh Savings = 500 hours * BTU/h Rating * (1/Fed Standard EER-1/Energy Star EER)/1000W/ kW

**Example** 5000 BTU/h, Old Unit EER = 7.5, Federal Standard = 9.7, new Energy Star unit EER = 10.7
First 4 years of savings
Annual kWh Savings = 500 hours * 5,000 BTU/h * (1/7.5-1/10.7)/1000W/ kW = 100
Remaining years of measure life savings
Annual kWh Savings = 500 hours * 5,000 BTU/h * (1/9.7-1/10.7)/1000W/ kW = 25

Note: Retirement savings (first 4 years) may only be claimed if retirement is program induced.

***Method for Calculating Demand Savings***

Demand savings in kW is calculated by multiplying the annual savings in kWh by a summer system peak kW/kWh factor found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

The Energy Star baseline EER is 10.7 BTU/W for less than 8,000 Btu/h units.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is the Energy Star Efficiency mentioned above.

***Operating Hours***

The full load operating hours for CT are assumed to be 500 hours per year.

***Total Cost***

Since this is a low income measure, all of the costs are borne by the program. The estimated total cost is $175 for the air conditioner plus $40 for demanufacturing, plus
$15 for delivery and pickup. For a 5,000 Btu unit the cost would be $115 + $40 + $15.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

06

## 6.2.8 DUCTLESS HEAT PUMP

***Description of Measure***

Ductless heat pumps.

***Method for Calculating Energy Savings***

Heating Savings is calculated using the lesser of the heating capacity of the unit(s) OR the load of the house, the region IV HSPF, and 1500 full load hours. Estimated heating savings should be compared with bill data for reasonableness.

Annual Energy (heating) Savings = 1,500 x Size (1/HSPF(baseline) – 1/HSPF(new)) / 1000

Where:
1,500 = estimated annual full-run hours
Size = size of system in Btu
HSPF = Heating Season Performance Factor

Cooling savings is calculated using the rated SEER and 500 full load hours.

Annual Energy (cooling) Savings = 500 x size (1/SEER(baseline) – 1/SEER(new)) / 1000

Where:
500 = expected annual full-run hours.
Size = size of system in Btu
SEER = Seasonal Energy Efficiency Ratio

***Method for Calculating Demand Savings***

Demand Savings is calculated using the peak factors in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

For retrofit, baseline efficiency is the actual existing efficiency for both heating and cooling. In situations where the actual baseline efficiency us unknown, use the following table:

| **Technology** | **Baseline Retrofit Efficiency** | **Baseline New Construction** |
|---|---|---|
| Electric Resistance Heating | 3.41 HSPF | N/A |
| Heat Pump (heating) | 5.0 HSPF | 7.7 HSPF |
| Window AC | 7.5 SEER/EER | 13 SEER |
| Central AC (or heat pump) Cooling | 10 SEER | 13 SEER |
| NO AC Present | 0 (negative cooling savings) | 13 SEER |

***Operating Hours***

1500 hours heating
500 hours cooling

***Incremental Cost***

For retrofit, the incremental cost is assumed to be $4000 + $2,000*(# of zones-1).
i.e. one zone costs $4,000, two zones cost $6,000 etc. A “zone” is a separate air handler regardless of the number of condensing units.

For new construction, the incremental cost is $500 plus $250 for each additional zone.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Revision Number***

01

# 6.3.1 WATER HEATER THERMOSTAT SETTING

***Description of Measure***

This measure is for lowering of the hot water temperature in an electric domestic hot water heater.

***Method for Calculating Energy Savings***

Please see the table below: Savings will occur only when the lower temperature of the hot water does not require the use of more hot water. Savings will not occur in an application such as a shower where the user demands a certain water temperature and will increase the hot water flow to make up for the lower temperature. A realization rate of 50 % has been applied to the faucet since savings will result only when the hot water is being wasted, and not when the user requires a certain temperature and increases the water flow to compensate for the reduced temperature.

**Lower Electric Water Heater Temp from 140 to 125F**

| | Faucet | Clothes Washer | Totals |
|---|---|---|---|
| **Water Consumption** | | | |
| Best available efficient aerator GPM | 1.5 | | |
| Duration of use, minutes | 0.5 | | |
| No of uses / day | 30 | | |
| Days/year | 260 | | |
| **Gallons of hot water used / year** | **5,850** | **2080** | **7,930** |
| **Consumption / cycle gallons hot water** | | 10 | |
| **Cycles/week** | | 4 | |
| **Energy Savings** | | | |
| **Btu** | | | |
| Temp water to house in degrees F | 55 | 55 | |
| Original hot water temp in degrees F | 140 | 140 | |
| Reset water temp in degrees F | 125 | 120 | |
| Temp savings in degrees F | 15 | 15 | |
| Weight of water pounds/gal | 8.3 | 8.3 | |
| Btu savings /gal | 124.5 | 124.5 | |
| Btu saved /year | 728,325 | 258,960 | |
| MBtu saved/year | 0.728 | 0.259 | |
| **kWh Electricity** | | | |
| kWh/Mbtu | 293 | 293 | |
| **Elect saved/year in kWh** | **213** | **76** | |
| Efficiency of electric hot water | 0.9 | 0.9 | |
| **Total Elect saved/year kWh at water heater** | **237** | **84** | |
| **Apply realization rate of 50% to faucet savings** | **118.5** | **84** | **202.5** |
| **Natural Gas** | | | |
| Gas saved/ year in MBtu | 0.728 | 0.259 | |
| Efficiency of gas water heater | 0.6 | 0.6 | |

**Lower Electric Water Heater Temp from 140 to 125F**

| | Faucet | Clothes Washer | Totals |
|---|---|---|---|
| Gas Saved/year in MBtu at water heater (1,000 Cu ft) | **1.213** | **0.43** | |
| **Apply realization rate of 50% to faucet savings** | **0.61** | **0.43** | **1.04** |
| | | | |
| **No.2 Oil** | | | |
| No 2 Oil, Btu/gal | | | 140,000 |
| Gallons of No. 2 oil saved / year | 5.2 | 1.8 | |
| Efficiency of oil fired heater | 0.5 | 0.5 | |
| **Gallons of No 2 oil saved at heater** | **10.4** | **3.6** | |
| | | | **8.8** |
| **Apply realization rate of 50% to faucet savings** | **5.2** | **3.6** | |

***<u>Method for Calculating Demand Savings</u>***

There is no demand savings associated with this measure.

***<u>Baseline Efficiencies from which savings are calculated</u>***

The base line efficiency is considered to be the 140F water heater outlet temperature.

***<u>Compliance Efficiency from which incentives are calculated</u>***

The compliance efficiency is considered to be the 125F water heater outlet temperature.

***<u>Operating Hours</u>***

The operating hours are included in the water consumption values in the table.

***<u>Total Cost</u>***

Since this is a low income measure, it is commonly done by a contractor and has a total cost of $5.

***<u>Non-Electric Benefits - Annual Fossil Fuel Savings</u>***

See Method for Calculating Energy Savings.

***<u>Non-Electric Benefits - Annual Water Savings</u>***

See Method for Calculating Energy Savings.

***<u>Revision Number</u>***

06

# 6.3.3 LOW FLOW SHOWERHEAD

***Description of Measure***

This measure is for the installation of 2.2 GPM low flow showerheads

***Method for Calculating Energy Savings***

The savings are estimated as shown in the table below.

| | | | | | |
|---|---|---|---|---|---|
| **Water Savings = ((Act.GPM - 2.2 GPM) X (min/shr) X (shr /day) X (days/y)) Gal/y** | | | | | |
| Actual shower flow in GPM as found | 3 | 3.5 | 4 | 4.5 | 5 |
| Federal standard for new construction | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Savings in Gal/min | 0.8 | 1.3 | 1.8 | 2.3 | 2.8 |
| Duration of use, minutes | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| No. of showers/day | 2 | 2 | 2 | 2 | 2 |
| Days/year | 365 | 365 | 365 | 365 | 365 |
| Gallons of Water Saved/year | **1,460** | **2,373** | **3,285** | **4,198** | **5,110** |
| | | | | | |
| **Energy Sav =((Water sav X (Temp to shr-temp to htr) X (8.3) / (1,000,000)) Mbtu/y** | | | | | |
| BTU | | | | | |
| Temp water to house in degrees F | 55 | 55 | 55 | 55 | 55 |
| Temperature water to shower in degree F | 105 | 105 | 105 | 105 | 105 |
| Delta temp in degrees F | 50 | 50 | 50 | 50 | 50 |
| Weight of water pounds/gal | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 |
| BTU required/gal | 415 | 415 | 415 | 415 | 415 |
| MBtu saved /year | **0.606** | **0.985** | **1.363** | **1.742** | **2.121** |
| | | | | | |
| **Elect. Sav = ((Sav at shower in Mbtu/y) X (293) / (0.9 assumed efficiency)) kWh/y** | | | | | |
| kWh/Mbtu | 293 | 293 | 293 | 293 | 293 |
| Elect. saved/year in kWh at showerhead | 177.5 | 288.5 | 399.4 | 510.4 | 621.4 |
| Efficiency of electric hot water heater | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Total elect. saved/year kWh at water heater | **197.3** | **320.5** | **443.8** | **567.1** | **690.4** |
| | | | | | |
| **Nat Gas Sav = ((Sav at shr in Mbtu/y) / (0.6 assumed efficiency) / (1000,000))Mbtu/y** | | | | | |
| Gas saved/year in MBTU at showerhead | 0.606 | 0.985 | 1.363 | 1.742 | 2.121 |
| Estimated efficiency of gas water heater | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Gas in MBTU at water heater | **1.010** | **1.640** | **2.270** | **2.900** | **3.530** |
| | | | | | |
| **No. 2 Oil Sav = ((Sav at shr in Mbtu) / (140,000) /** | **(0.5 assumed efficiency)) Gal/y** | | | | |
| No 2 Oil, BTU/gal | 140,000 | 140,000 | 140,000 | 140,000 | 140,000 |
| Gallons of No. 2 oil saved/year at faucet | 4.33 | 7.04 | 9.74 | 12.44 | 15.15 |
| Estimated efficiency of oil fired hot water heater | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Gallons of No 2 oil saved at water heater | **8.66** | **14.08** | **19.48** | **24.88** | **30.30** |

***Method for Calculating Demand Savings***

There is no demand savings associated with this measure.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the Federal Standard showerhead with a flow rate of 2.5 gpm at 80 psi.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is 2.2gpm

***Operating Hours***

The operating hours can be calculated from the use time in the table above.

***Total Cost***

Since this measure is used in the Low Income Program, there is no cost to the resident. The total cost for material and installation is $8.10.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The equivalent fossil fuel savings for this measure is shown above in MBtu of gas and gallons of No. 2 oil.

***Non-Electric Benefits - Annual Water Savings***

The annual water savings is shown in the table above in gallons/year.

***Revision Number***

08

# 6.3.4 WATER HEATER WRAP

***Description of Measure***

Electric Hot water heaters with fiberglass insulation are wrapped with an insulating blanket to reduce standby heat loss through the skin. This measure is not necessary for newer units which are insulated with foam.

***Method for Calculating Energy Savings***

The reference used for this measure is "Meeting the Challenge: The Prospect of Achieving 30 percent Energy Savings Through the Weatherization Assistance Program" by the Oak Ridge National Laboratory - May 2002.

The home studied in the Northeast had a gas fired water heater, and was not applicable, since only electric water heaters are wrapped in the Low Income programs. The southern home in the study did have an electric water heater. The difference in the actual heating and storage of hot water may be a little different in the South versus the Northeast, but the southern home can still be used as a good approximation.

The temperature of the water entering the heater may be warmer in the South versus the Northeast, especially in the Winter, but this would not affect standby losses which the wrapping seeks to reduce. The other difference is that the heat loss from the tank to the environment may be greater in the Northeast than the South because of the more mild Southern winters and the warmer southern summers. Therefore the Southern house can be used as a good approximation to a house in the Northeast with a possible slight upward bias.

The Oak Ridge study predicted that wrapping a 40 gallon water heater would result in an increase in the energy factor form 0.86 to 0.88 with a resulting savings of 0.20 MBTU. The electric equivalent of 0.20 MBtu is 0.2 X 293 kWh/MBtu = 58.6 kWh. Adjusting upward for a house in Connecticut, the estimated annual savings is approximately 70 kWh.

***Method for Calculating Demand Savings***

The demand saving is calculate by multiplying the annual kWh savings by the summer or winter peak factor for domestic hot water found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

The base line efficiency used is that of a foam-insulated electric water heater with an energy factor of 0.86.

***Compliance Efficiency from which incentives are calculated***

The tank must have fiberglass insulation.

***Operating Hours***

Operating hours are used in the heat loss calculations, but only the result of those calculations is used here.

***Total Cost***

Since this is a low income program, the entire cost is borne by the program. The estimated cost is $16.00 for the material and $8.00 for the labor.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

The reference used for this measure is “Meeting the Challenge: The Prospect of Achieving 30 percent Energy Savings Through the Weatherization Assistance Program” by the Oak Ridge National Laboratory - May 2002.

***Revision Number***

04

## 6.3.5 FAUCET AERATOR

### ***Description of Measure***

Replacement of federal standard 2.2 gpm faucet aerators with best available aerators.

### ***Method for Calculating Energy Savings***

The savings are estimated as shown below and are based on US Federal Energy Management Program assumptions.

| **Faucet Aerators Water and Energy Savings** | |
|---|---|
| **Water Savings** | |
| Best available efficient aerator GPM | 1.5 |
| Fed Standard for New Construction GPM | 2.2 |
| Savings GPM | 0.7 |
| Duration of use, minutes | 0.5 |
| No of uses/day | 30 |
| Days/year | 260 |
| **Gallons of Water Saved/year** | **2,730** |
| **Energy Savings** | |
| Temp water to house in degrees F | 55 |
| Water use temp in degrees F | 80 |
| Delta temp In degrees F | 25 |
| Weight of water pounds/gal | 8.3 |
| BTU required/gal | 207.5 |
| BTU saved /year | 566,475 |
| MBTU saved/year | 0.566 |
| **kWh Electricity** | |
| kWh/MBTU | 293 |
| **Elect saved/year in kWh at faucet** | **166** |
| Efficiency of electric hot water | 0.9 |
| **Total Elect saved/year kWh at water heater** | **184** |
| **Natural Gas** | |
| Gas saved/ year in MBTU at faucet | 0.566 |
| Efficiency of gas water heater | 0.6 |
| Gas Saved/year in MBTU at water heater (1,000 Cu ft) | **0.944** |
| **No.2 Oil** | |
| No 2 Oil, BTU/gal | 140,000 |
| Gallons of No 2 oil saved/year at faucet | **4.046** |
| Efficiency of oil fired heater | 0.5 |
| **Gallons of No 2 oil saved at heater** | **8.0925** |

***Method for Calculating Demand Savings***

There is no demand savings associated with this measure.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the flow rate of an aerator meeting the federal standard of 2.2 gpm.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is 1.5 gpm.

***Operating Hours***

The operating hours assumed are 0.5 minutes/use X 30 uses/day X 260 days/year/60 minutes/hour = 65 hours/year.

***Total Cost***

The total installed cost in the Low Income program is $3.50

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The annual expected non-electric benefits are shown in shown in " Method for Calculating Energy Savings."

***Non-Electric Benefits - Annual Water Savings***

The annual expected water savings is shown in shown in " Method for Calculating Energy Savings."

***Revision Number***

05

## 6.3.6 FLIP AERATOR

***Description of Measure***

This measure is for the installation of 1.5 gpm flip (shut-off type) type aerators

***Method for Calculating Energy Savings***

The savings are estimated as shown below and are based on US Federal Energy Management Program assumptions.

| | |
|---|---|
| **Faucet Aerators Water and Energy Savings** | |
| | |
| **Water Savings** | |
| Best available efficient aerator GPM | 1.5 |
| Fed Standard for New Construction GPM | 2.2 |
| Savings GPM | 0.7 |
| Duration of use, minutes | 0.5 |
| No of uses/day | 30 |
| Days/year | 260 |
| **Gallons of Water Saved/year** | **2,730** |
| | |
| **Energy Savings** | |
| Temp water to house in degrees F | 55 |
| Water use temp in degrees F | 80 |
| Delta temp In degrees F | 25 |
| Weight of water pounds/gal | 8.3 |
| BTU required/gal | 207.5 |
| BTU saved /year | 566,475 |
| MBTU saved/year | 0.566 |
| | |
| **kWh Electricity** | |
| kWh/MBTU | 293 |
| **Elect saved/year in kWh at faucet** | **166** |
| Efficiency of electric hot water | 0.9 |
| **Total Elect saved/year kWh at water heater** | **184** |
| | |
| **Natural Gas** | |
| Gas saved/ year in MBTU at faucet | 0.566 |
| Efficiency of gas water heater | 0.6 |
| Gas Saved/year in MBTU at water heater (1,000 Cu ft) | **0.944** |
| | |
| **No.2 Oil** | |
| No 2 Oil, BTU/gal | 140,000 |
| Gallons of No 2 oil saved/year at faucet | **4.046** |
| Efficiency of oil fired heater | 0.5 |
| **Gallons of No 2 oil saved at heater** | **8.0925** |

***Method for Calculating Demand Savings***

There is no demand savings associated with this measure.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is the flow rate of an aerator meeting the federal standard of 2.2 gpm.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is 1.5 gpm.

***Operating Hours***

The operating hours assumed are 0.5 minutes/use X 30 uses/day X 260 days/year/60 minutes/hour = 65 hours/year.

***Total Cost***

The total installed cost in the Low Income program is $5.00

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The non-electric savings are shown in “Method for Calculating energy savings.”

***Non-Electric Benefits - Annual Water Savings***

The water savings is shown in “ Method for Calculating Energy Savings”)

***Revision Number***

05

## 6.3.7 REFRIGERATOR REPLACEMENT

***Description of Measure***

This measure is for the replacement of old refrigerators in the UI and CL&P Low Income programs.

***Method for Calculating Energy Savings***

The measure life for this program is 20 years. However, the first 10 years savings are based on the old refrigerator and the remaining 10 years savings are based on the new energy star refrigerator. It is assumed that the refrigerators would continue in daily operation for another 10 years without the replacement program. It is assumed that the refrigerators are not replaced by the owners.

The savings is calculated by taking the annual electric consumption from name plate information for 18-cubic-foot refrigerators received from customers in UI's Low Income Program, and subtracting the predicted annual electric consumption for new, Kenmore 18-cubic-foot Energy Star refrigerators with automatic defrost and top mounted freezers.

The average consumption of the old 18-cubic-foot refrigerators for program planning purposes is taken as 1193 kWh/year, and the predicted consumption for a similar new model is 407 kwh/year. The savings is 1193- 407 = 786 kWh/year for the first 10 years. The remaining 10 years of savings are determined using measure 5.3.9.

Note: Retirement savings may only be claimed if retirement is program induced.

***Method for Calculating Demand Savings***

The demand savings for the summer peak period is calculated by multiplying the annual kWh savings by the summer peak demand factor found in Appendix Table 1.1.3

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is that of a new Federal Standard refrigerator and is 481 kWh/year for this model.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is that of a new Energy Star model and in this case is 407 kWh/year.

***Operating Hours***

The operating hours are included in the annual electric consumption.

***Total Cost***

The cost for purchase and installation is $510.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

The reference used in the above analysis is the US EPA's Energy Star website.

***Revision Number***

05

# 6.3.8 FREEZER REPLACEMENT

***Description of Measure***

Replacement of old Freezers with Energy Star Models in the Low Income Programs.

***Method for Calculating Energy Savings***

The savings is calculated by taking the predicted annual consumption from the nameplate data and subtracting the predicted annual consumption of the new model. For program planning purposes the savings is calculated by taking the difference in the average annual electric consumption for a 10.4 cubic foot upright freezer (353 kWh/y. Size does not matter much since a 20.3 cubic foot freezer consumes only 415 kWh.) and the expected consumption of an old freezer which is estimated to be about 75% of that of an old refrigerator replaced in the Low Income 75% X 1193kWh = 895. So 895 – 353 = 542 kWh.

The measure life for this program is 20 years. However, the first 10 years savings (542 kWh) are based on the old freezer and the remaining 10 years savings are based on the new energy star freezer verses the baseline. It is assumed that the freezers would continue in daily operation for another 10 years without the replacement program. It is assumed that the freezers are not replaced by the owners.

Note: Retirement savings may only be claimed if retirement is program induced.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential refrigeration found in Appendix Table 1.1.3.

***Baseline Efficiencies from which savings are calculated***

The baseline efficiency is that of a new Federal Standard freezer.

***Compliance Efficiency from which incentives are calculated***

The compliance efficiency is that of a new Energy Star model and in this case is 353 kWh/year.

***Operating Hours***

The operating hours are not a factor in this analysis.

***Total Cost***

Since this is a low income program, the freezers are furnished at no cost to the customer. The cost for purchase and installation is estimated at $400.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-electric benefits have not been identified for this measure.

***Notes & References***

The reference used in the above analysis is the US EPA's Energy Star website.

***Revision Number***

04

## 6.4.1 ELECTRICAL OUTLET GASKETS

***Description of Measure***

Outlet gasket placed on exterior wall OR wall that communicates directly with unconditioned space.

***Method for Calculating Energy Savings***

Annual savings per outlet cover (for homes with electric heat):

Electric resistance savings = 14 kWh (note 1)
Heat Pump savings = 7 kWh

The above default values should be used only if Blower Door (refer to section 5.4.4) testing is not possible or practical. Savings estimates based on actual measured infiltration reduction (through blower door testing) are more precise.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3

***Total Cost***

Actual cost OR $1 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Savings (per gasket) = 0.064 MBtu
Annual gas savings = 0.64 Therms/year (for gas heated homes)
Annual oil savings = 0.46 Gallons/year (for oil heated homes)
Annual propane = 0.71 Gallons/year (for propane heated homes)

***Notes & References***

Note 1: Savings calculated by Joe Swift, Northeast Utilities, 2005.

***Revision Number***

04

## 6.4.2 DOOR SWEEP

***Description of Measure***

Door sweep installed on exterior door.

***Method for Calculating Energy Savings***

Annual savings (for homes with electric heat):

Electric resistance savings = 132 kWh (note 1)
Heat Pump savings = 66 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3

***Total Cost***

Actual cost OR $20 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Savings (per door sweep) = 0.60 MBtu
Annual gas savings = 6.0 Therms/year (for gas heated homes)
Annual oil savings = 4.3 Gallons/year (for oil heated homes)
Annual propane = 6.6 Gallons/year (for propane heated homes)

***Notes & References***

Note 1: Savings estimate from NU Low Income Tracking system (2005). Reviewed by Joe Swift, Northeast Utilities and deemed appropriate.

***Revision Number***

03

## 6.4.3 DOOR KIT

***Description of Measure***

Installation of a door kit to reduce infiltration.

***Method for Calculating Energy Savings***

Savings assumed to be the same as the savings for a door sweep (Measure 6.4.2).

Annual savings (for homes with electric heat):

Electric resistance savings = 132 kWh
Heat Pump savings = 66 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3

***Total Cost***

Actual cost OR $20 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Savings (per door sweep) = 0.60 MBtu
Annual gas savings = 6.0 Therms/year (for gas heated homes)
Annual oil savings = 4.3 Gallons/year (for oil heated homes)
Annual propane = 6.6 Gallons/year (for propane heated homes)

***Revision Number***

02

# 6.4.5 CAULKING & SEALING

***Description of Measure***

Caulking or sealing of linear cracks in building shell for the purpose of reducing infiltration. Caulking or sealing for the purpose of controlling moisture does not qualify unless there is documented evidence that infiltration is being reduced. Examples of this measure would include caulking under the baseboard on exterior walls, or the use of caulk to air-seal recessed lights. Sealing a roof or installing flashing on the exterior of a building would not qualify since the purpose of this measure would be to control moisture and it would have very little effect on infiltration. To reduce the chance of gaming, savings (infiltration reductions) achieved through this measure should be verified through the use of a blower door with the blower door results taking precedence of the savings values presented here.

***Method for Calculating Energy Savings***

Engineering estimate was used to calculate expected amount of savings based on 10 linear feet of sealing (Note 1).

Annual Savings (for homes with electric heat):

Electric resistance savings = 74 kWh per 10 linear feet
Heat Pump savings = 37 kWh per 10 linear feet.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3

***Total Cost***

$50 per person-hour plus materials or actual cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Savings (per 10 linear feet of caulk) = 0.34 MBtu
Annual gas savings = 3.4 Therms/year (for gas heated homes)
Annual oil savings = 2.4 Gallons/year (for oil heated homes)
Annual propane = 3.8 Gallons/year (for propane heated homes)

***Notes & References***

Note 1. Estimate by Joe Swift, Northeast Utilities, 2005.

***Revision Number***

02

## 6.4.6 POLYETHYLENE TAPE

***Description of Measure***

Polyethylene taping of linear cracks in building shell for the purpose of reducing infiltration. Tape must only be applied to areas that areas where drafts are noticeable in order to qualify for savings. Similar to caulking, the savings for this measure should be verified with a blower door (see blower door savings 6.4.14) with the blower door savings taking over-riding the savings values presented here.

***Method for Calculating Energy Savings***

Engineering estimate was used to calculate expected amount of savings based on 10 linear feet of sealing (Note 1).

Annual Savings (for homes with electric heat):

Electric resistance savings = 74 kWh per 10 linear feet
Heat Pump savings = 37 kWh kWh per 10 linear feet.

The above default values should be used only if Blower Door (refer to section 5.4.4) testing is not possible or practical. Savings estimates based on actual measured infiltration reduction (through blower door testing) are more precise.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.

***Total Cost***

$50 per person-hour plus materials or actual cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Savings (per 10 linear feet of caulk) = 0.34 MBtu
Annual gas savings = 3.4 Therms/year (for gas heated homes)
Annual oil savings = 2.4 Gallons/year (for oil heated homes)
Annual propane = 3.8 Gallons/year (for propane heated homes)

***Notes & References***

Note 1. Joe Swift, Northeast Utilities, 2005.

***Revision Number***

03

## 6.4.7 WEATHERSTRIP WINDOW

***Description of Measure***

Weatherstrip installed on a window.

***Method for Calculating Energy Savings***

Annual savings (for homes with electric heat):

Electric resistance savings = 70 kWh (note 1)
Heat Pump savings = 35

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating shown in appendix Table 1.1.3.

***Total Cost***

Actual cost OR $20 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.
The savings for other types of fuel can be calculated from the electric savings value.

Annual fossil fuel savings = 70 kWh/year x 3413 Btu/kwh / 75% = 318,547 Btu/year

where: 3413 converts from kWh to Btu
75% is the assumed system efficiency including distribution loss.

Therefore,
annual gas savings = 3.2 Therms/year (for gas heated homes)
annual oil savings = 2.3 Gallons/year (for oil heated homes)
annual propane = 3.5 Gallons/year (for propane heated homes)

***Notes & References***

Note 1: Savings estimate from NU Low Income Tracking system (2005). Reviewed by Joe Swift, Northeast Utilities and deemed appropriate.

***Revision Number***

03

## 6.4.8 WEATHERSTRIP DOOR

***Description of Measure***

Weatherstrip installed on exterior door.

***Method for Calculating Energy Savings***

Annual savings (for homes with electric heat):

Electric resistance savings = 120 kWh (note 1)
Heat Pump savings = 60 kWh

The above default values should be used only if Blower Door (refer to section 5.4.4) testing is not possible or practical. Savings estimates based on actual measured infiltration reduction (through blower door testing) are more precise.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.

***Total Cost***

Actual cost or $20 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.
The savings for other types of fuel can be calculated from the electric savings value.

Annual fossil fuel savings = 120 kWh/year x 3413 Btu/kwh / 75% = 546,080 Btu/year

where: 3413 converts from kWh to Btu
75% is the assumed system efficiency including distribution loss.

Therefore,
annual gas savings = 5.5 Therms/year (for gas heated homes)
annual oil savings = 3.9 Gallons/year (for oil heated homes)
annual propane = 6.1 Gallons/year (for propane heated homes)

***Notes & References***

Note 1: Savings estimate from NU Low Income Tracking system (2005). Reviewed by Joe Swift, Northeast Utilities and deemed appropriate.

***Revision Number***

02

# 6.4.9 INSULATE ATTIC HATCH

***Description of Measure***

Insulation and weatherstripping applied to an attic hatch (approximately 6 square feet assumed).

***Method for Calculating Energy Savings***

**Btu Annual Savings = (Conductive savings) + (Infiltration savings)**

1) **Conductive Savings** = $(1/R_{existing} - 1/R_{New})$ x Degree Days x 24 x Adjustment x Area

where: $R_{existing}$ is the R-value of the current hatch, assumed to be 1.0
$R_{New}$ is the upgraded (with pane) R-value, assumed to be 20
Degree days = 6200 assumed state average
Adjustment = 0.64 ASHRAE adjustment factor (note 1)
Area = size of attic hatch in square feet, assumed to be 6.

Annual Btu conductive saving = 542,882 Btu

2) **Infiltration Savings** = 600,000 MBtu estimated based on geometry of opening (Note 2).

**Total Btu savings 1,143,000** *(rounded)*

Therefore, Annual Savings (for homes with electric heat):
Electric resistance savings = 335 kWh
Heat Pump savings = 167 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.

***Total Cost***

Actual cost or $40 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Annual fossil fuel savings = MBtu savings / system efficiency

where: MBtu savings = 1.143
75% is the assumed system efficiency including distribution loss.

Therefore,
annual gas savings = 11.4 Therms/year (for gas heated homes)
annual oil savings = 8.2 Gallons/year (for oil heated homes)
annual propane = 12.7 Gallons/year (for propane heated homes)

***Notes & References***

Note 1. ASHRAE degree-day correction. 1989 ASHRAE Handbook Fundamentals 28.2, Fig 1
Note 2. Estimate by Joe Swift, Northeast Utilities, 2005.

***Revision Number***

02
03

# 6.4.10 REPAIR WINDOW

***Description of Measure***

General repair of a window which is expected to produce energy savings (i.e. fix broken pane, caulk, etc.)

***Method for Calculating Energy Savings***

The savings for this measure will vary greatly depending on the condition of the window and type of repair. Therefore, defining an average savings is difficult. Consideration should be given to making this a custom measure (depending on the scope and size of the project). With that said, for the purpose of coming up with a default savings, it is assumed that an average window repair will increase the efficiency to the same magnitude as weather-stripping an average window. Therefore, savings is equal to the savings for weatherstripping a window (measure 6.4.7).

Annual savings (for homes with electric heat):

Electric resistance savings = 70 kWh (note 1)
Heat Pump savings = 35 kWh (assumed COP of 2.0).

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.

***Total Cost***

Actual cost or $20 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating. The savings for other types of fuel can be calculated from the electric savings value.

Annual fossil fuel savings = 70 kWh/year x 3413 Btu/kwh / 75% = 318,547 Btu/year

where: 3413 converts from kWh to Btu
75% is the assumed system efficiency including distribution loss.

Therefore,
annual gas savings = 3.2 Therms/year (for gas heated homes)
annual oil savings = 2.3 Gallons/year (for oil heated homes)
annual propane = 3.5 Gallons/year (for propane heated homes)

***Revision Number***

03

# 6.4.11 WINDOW UPGRADE

***Description of Measure***

Installing a storm panel (storm window) on an existing single pane window. Average size assumed to be 12 square feet.

***Method for Calculating Energy Savings***

Btu Savings = ($1/R_{existing} – 1/R_{New}$) x Degree Days x 24 x Adjustment x Area

where:
$R_{existing}$ is the R-value of the current window, assumed to be 1.0
$R_{New}$ is the upgraded (with pane) R-value, assumed to be 3.0
Degree days = 6200 assumed state average
Adjustment = 0.64 ASHRAE adjustment factor (note 1)
Area = size of window in square feet, assumed to be 12.

Annual Btu saving from above = 761,856 Btu = 0.762 MBtu

Electric resistance heat, savings = 223 kWh
Heat pump savings = 112 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.

***Total Cost***

Actual cost or $50 assumed installed cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Annual fossil fuel savings = MBtu savings / system efficiency

where: MBtu savings = 0.762
75% is the assumed system efficiency including distribution loss.

Therefore,
Annual savings = 1.02 MBtu
Annual gas savings = 10.2 Therms/year (for gas heated homes)
Annual oil savings = 7.3 Gallons/year (for oil heated homes)
Annual propane = 11.3 Gallons/year (for propane heated homes)

***Notes & References***

Note 1. ASHRAE degree-day correction. 1989 ASHRAE Handbook Fundementals 28.2, Fig 1

***Revision Number***

03

## 6.4.12 INSTALL CEILING INSULATION

***Description of Measure***

Installation of ceiling insulation in a residential living unit. The type of insulation installed is assumed to be either loose fill or batt-type insulation. Insulation must be installed between conditioned area and ambient (attic or outside) space. Insulation that is installed between two living spaces (i.e. between floors on a two family unit) does not qualify.

***Method for Calculating Energy Savings***

A parallel flow analysis was conducted (Note 1) and the following charts were generated. The R-value refers to the rated R-value of the insulation. The effective ceiling R-value and heat transfer was calculated to generate these charts. Note that the savings is based on 100 square feet of ceiling area.

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 1,390 | 1,405 | 1,435 | 1,445 | 1,454 | 1,467 | 1,476 |
| **3** | 424 | 439 | 469 | 479 | 488 | 501 | 510 |
| **6** | 214 | 229 | 259 | 269 | 277 | 290 | 300 |
| **9** | 122 | 136 | 167 | 177 | 185 | 198 | 208 |
| **12** | 70 | 85 | 115 | 125 | 134 | 147 | 156 |
| **15** | 37 | 52 | 82 | 92 | 101 | 114 | 123 |
| **19** | | 15 | 45 | 55 | 64 | 77 | 86 |
| **21** | | | 30 | 41 | 49 | 62 | 71 |
| **27** | | | | 10 | 19 | 32 | 41 |

Annual kWh Savings for Electric Resistance Heat (per 100 sq. ft.)

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 695 | 702 | 718 | 723 | 727 | 733 | 738 |
| **3** | 212 | 219 | 235 | 240 | 244 | 250 | 255 |
| **6** | 107 | 114 | 129 | 135 | 139 | 145 | 150 |
| **9** | 61 | 68 | 83 | 88 | 93 | 99 | 104 |
| **12** | 35 | 42 | 57 | 63 | 67 | 73 | 78 |
| **15** | 18 | 26 | 41 | 46 | 50 | 57 | 61 |
| **19** | | 7.47 | 23 | 28 | 32 | 38 | 43 |
| **21** | | | 15 | 20 | 24 | 31 | 36 |
| **27** | | | | 5 | 9 | 16 | 21 |

Annual kWh Savings for Electric Heat Pump (per 100 sq. ft.)

For example, suppose a house with electric resistance heat currently has 2 inches (assumed R-6) insulation in the attic. Insulation is installed to bring the total R-value up to R-30. The savings would be calculated by locating the R-6 on the left-hand column (pre-existing condition) and following across the row to R-30 (Total Post-installed R-value). For electric heat, the savings would be 269 kWh per 100 square feet of ceiling area.

In cases where the exact R-value (either pre or post) falls between the values on these tables, linear extrapolation can be used to approximate the savings.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.

Cooling savings is not defined for this measure.

***Total Cost***

Actual cost or $1 per square foot as a default.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

The following charts can be used to calculate fossil fuel savings for ceiling insulation. These charts are similar in nature to the charts above.

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 45.2 | 45.7 | 46.6 | 47.0 | 47.3 | 47.7 | 48.0 |
| **3** | 13.8 | 14.3 | 15.2 | 15.6 | 15.9 | 16.3 | 16.6 |
| **6** | 6.9 | 7.4 | 8.4 | 8.7 | 9.0 | 9.4 | 9.7 |
| **9** | 4.0 | 4.4 | 5.4 | 5.8 | 6.0 | 6.4 | 6.8 |
| **12** | 2.3 | 2.8 | 3.7 | 4.1 | 4.3 | 4.8 | 5.1 |
| **15** | 1.2 | 1.7 | 2.7 | 3.0 | 3.3 | 3.7 | 4.0 |
| **19** | | 0.5 | 1.5 | 1.8 | 2.1 | 2.5 | 2.8 |
| **21** | | | 1.0 | 1.3 | 1.6 | 2.0 | 2.3 |
| **27** | | | | 0.3 | 0.6 | 1.0 | 1.3 |

Annual Gallons of Oil Saved (per 100 sq. ft.)

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 63.3 | 63.9 | 65.3 | 65.8 | 66.2 | 66.7 | 67.2 |
| **3** | 19.3 | 20.0 | 21.3 | 21.8 | 22.2 | 22.8 | 23.2 |
| **6** | 9.7 | 10.4 | 11.8 | 12.2 | 12.6 | 13.2 | 13.6 |
| **9** | 5.5 | 6.2 | 7.6 | 8.1 | 8.4 | 9.0 | 9.5 |
| **12** | 3.2 | 3.9 | 5.2 | 5.7 | 6.1 | 6.7 | 7.1 |
| **15** | 1.7 | 2.4 | 3.7 | 4.2 | 4.6 | 5.2 | 5.6 |
| **19** | | 0.7 | 2.1 | 2.5 | 2.9 | 3.5 | 3.9 |
| **21** | | | 1.4 | 1.8 | 2.2 | 2.8 | 3.2 |
| **27** | | | | 0.5 | 0.9 | 1.4 | 1.9 |

Annual Therms of Gas Saved (per 100 sq. ft.)

| Pre-Existing Insulation R-value | Total Post-Installed R-Value (including pre-existing) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **19** | **21** | **27** | **30** | **33** | **39** | **45** |
| **0** | 70.3 | 71.0 | 72.6 | 73.1 | 73.5 | 74.2 | 74.6 |
| **3** | 21.4 | 22.2 | 23.7 | 24.2 | 24.7 | 25.3 | 25.8 |
| **6** | 10.8 | 11.6 | 13.1 | 13.6 | 14.0 | 14.7 | 15.2 |
| **9** | 6.1 | 6.9 | 8.4 | 8.9 | 9.4 | 10.0 | 10.5 |
| **12** | 3.5 | 4.3 | 5.8 | 6.3 | 6.8 | 7.4 | 7.9 |
| **15** | 1.9 | 2.6 | 4.1 | 4.7 | 5.1 | 5.7 | 6.2 |
| **19** | | 0.8 | 2.3 | 2.8 | 3.2 | 3.9 | 4.4 |
| **21** | | | 1.5 | 2.0 | 2.5 | 3.1 | 3.6 |
| **27** | | | | 0.5 | 0.9 | 1.6 | 2.1 |

Annual Gallons of Propane Saved (per 100 sq. ft.)

***Notes & References***

Note 1. Joe Swift, Northeast Utilities, 2002. Reviewed and updated in April, 2005.

***Revision Number***

03

# 6.4.13 INSTALL WALL INSULATION

***Description of Measure***

Insulation installed (either bat or blown-in) in a wall. Assuming that there is no insulation installed previously.

***Method for Calculating Energy Savings***

Parallel flow method was used to calculate savings (Note 1) based on a typical 2 x 4 wall.
Savings is based on 100 square feet of wall area (net of window and doors).

**Savings** = $(1/R_{existing} – 1/R_{New})$ x Degree Days x 24 x Adjustment x Area

where:
- $R_{existing}$ is the effective R-value of the existing wall assumed to be 3
- $R_{New}$ is the upgraded effective R-value assumed to be 10
- Degree days = 6200 assumed state average
- Adjustment = 0.64 ASHRAE adjustment factor (note 2)
- Area = 100 square feet .

Annual Btu conductive saving = 2,220,000

Therefore, Annual Savings (for homes with electric heat):
- Electric resistance savings = 651 kWh
- Heat Pump savings = 326 kWh

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.
Summer demand savings is zero.

***Total Cost***

Actual cost or $0.75 per square foot as default.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

Annual fossil fuel savings = MBtu savings / system efficiency

where: MBtu savings = 2.22
75% is the assumed system efficiency including distribution loss.

Therefore,
annual gas savings = 22.2 Therms/year (for gas heated homes)
annual oil savings = 15.9 Gallons/year (for oil heated homes)
annual propane = 24.7 Gallons/year (for propane heated homes)

***Notes & References***

Note 1. Joe Swift, Northeast Utilities, 2002. Reviewed and updated in April, 2005.

Note 2. ASHRAE degree-day correction. 1989 ASHRAE Handbook Fundamentals 28.2, Fig 1

***Revision Number***

03

## 6.4.14 CONDUCT BLOWER TEST

***Description of Measure***

Energy savings due to reductions in infiltration that are not covered by prescriptive measures. Savings under this measure must be verified by a blower door test and is determined by the difference in the two blower door readings. Blower door savings captures (and overrides) measure specific savings due to draft reducing measures that may have been installed during the improvement process.

***Method for Calculating Energy Savings***

Table 1 – Savings for new homes

| CFM 50 per square foot conditioned space | MBtu Heating Savings per 1000 sq ft | kWh Heating Savings (geothermal) per 1000 sq ft. | KWh Heating Savings (air handler/Fan systems only) | kWh Cooling Savings per 1000 sq ft |
|---|---|---|---|---|
| 1.00 | 0.0 | 0.0 | 0 | 0 |
| 0.95 | 0.3 | 26 | 3 | 13 |
| 0.90 | 0.7 | 51 | 6 | 26 |
| 0.85 | 1.0 | 77 | 8 | 39 |
| 0.80 | 1.4 | 102 | 11 | 52 |
| 0.75 | 1.7 | 128 | 14 | 65 |
| 0.70 | 2.1 | 154 | 17 | 78 |
| 0.65 | 2.4 | 180 | 19 | 91 |
| 0.60 | 2.8 | 205 | 22 | 104 |
| 0.55 | 3.1 | 231 | 25 | 117 |
| 0.50 | 3.5 | 156 | 28 | 130 |
| 0.45 | 3.8 | 282 | 30 | 143 |
| 0.40 | 4.2 | 308 | 34 | 156 |
| 0.35 | 4.5 | 334 | 36 | 169 |
| 0.30 | 4.9 | 359 | 39 | 273 |

*Blower Door Savings for New Homes (based on 1 CFM at 50 Pa per square foot conditioned floor area.*

Table 2 – Retrofit Savings

| Savings per 100 CFM (at 50 Pa) reduction | | |
|---|---|---|
| **Measure** | **Savings** | **Units** |
| Electric Resistance Heat | 156 | kWh |
| Heat Pump Heating | 78 | kWh |
| Geothermal Heating | 52 | kWh |
| Air Handler (fan) Heating | 6.4 | kWh |
| Fossil Fuel Heating | 0.8 | MBtu |
| Cooling | 45 | kWh |

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor for residential winter heating found in Appendix Table 1.1.3.

***Total Cost***

$50 per person-hour plus materials or actual cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Non-Electric savings would occur for homes that have a non-electric source of heating.

| MBtu Savings (from above) | Gallons Oil | Therms Gas | Gallons Propane |
|---|---|---|---|
| 0.0 | 0.0 | 0.0 | 0.0 |
| 0.1 | 0.7 | 1.0 | 1.1 |
| 0.2 | 1.4 | 2.0 | 2.2 |
| 0.3 | 2.1 | 3.0 | 3.3 |
| 0.4 | 2.9 | 4.0 | 4.4 |
| 0.5 | 3.6 | 5.0 | 5.6 |
| 0.6 | 4.3 | 6.0 | 6.7 |
| 0.7 | 5.0 | 7.0 | 7.8 |
| 0.8 | 5.7 | 8.0 | 8.9 |
| 0.9 | 6.4 | 9.0 | 10.0 |
| 1.0 | 7.1 | 10.0 | 11.1 |

***Revision Number***

05

## 6.4.15 WEATHERIZATION (CUSTOM MEASURE)

***Description of Measure***

A custom project is defined as a project for which accurate savings can not be determined through the existing defined measures. In order for a lighting project to be considered as "custom", it includes measures that are NOT defined in this manual, or there must be very strong and documented evidence that the current savings algorithms in this manual are clearly not appropriate to use.

For instance, foam insulation may be used to insulate and seal the attic of a house and the ducts within that space. In this case, the foam is performing many functions (insulating and sealing both attic and ducts) and the savings from this project would not be equal to the sum of its parts. One acceptable option would be to model this home using a home energy software and calculate the savings based on the foam "package".

***Method for Calculating Energy Savings***

The energy savings for custom projects is determined and documented on a case-by-case basis using commonly accepted engineering estimating techniques, approved energy simulation software, or through actual metering.

***Method for Calculating Demand Savings***

The peak demand savings is calculated by multiplying the annual kWh savings by the peak kW/kWh factor found in Appendix Table 1.1.

***Total Cost***

Actual Cost.

***Non-Electric Benefits - Annual Fossil Fuel Savings***

Since the majority of homes are heated with fossil fuel, fossil fuel heating savings will be a likely result of most weatherization measures.

***Revision Number***

03

# APPENDIX

## 7.1.1 TABLE 1.1 PEAK FACTORS

***Table 1.1.1 C&I Peak Coincidence Factors***

**Default Commercial and Industrial Peak Coincidence Factors**
**(at meter without line losses)**

Use this Table to determine demand (kW) savings at summer and winter peaks for program planning and reporting.

$$CF\_summer = \frac{kWh\_saved\_during\_the\_seasonal\_peak\_hours\_(90\%\_of\_the\_50/50\_peak\_forecast)\_June\_Aug}{(number\_of\_hours)*connected\_load(nameplate\_kW)}$$

$$CF\_winter = \frac{kWh\_saved\_during\_the\_seasonal\_peak\_hours\_(90\%\_of\_the\_50/50\_peak\_forecast)\_Dec\_Jan}{(number\_of\_hours)*connected\_load(nameplate\_kW)}$$

| | **HVAC** | | | | | | |
|---|---|---|---|---|---|---|---|
| | Unitary AC (No chillers) | Variable Frequency Drives | | | Heating | Efficient Motors | |
| | | Pumps | Fans | All | | Cooling | Heating |
| | | Avg of cooling and other | Avg of Air Handler Unit and Cooling tower | | | | |
| Summer | 0.82 | 0.55 | 0.28 | 0.44 | | 0.73 | |
| | | | AHU only | | | | |
| Winter | | 0.43 | 0.44 | 0.36 | * | 0.60 | 0.8 |

* Specific to each measure

| **Lighting Summer Seasonal Peak Hours (90% of 50/50 Peak Forecast)**<br><br>**Without Occupancy Sensors** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Grocery | 0.90 |
| Manufacturing | 0.67 |
| Medical (Hospital) | 0.74 |
| Office | 0.70 |
| Other | 0.48 |
| Restaurant | 0.78 |
| Retail | 0.80 |
| University/College | 0.65 |
| Warehouse | 0.73 |
| School | 0.60 |
| Total Equal Weight by Sector | 0.70 |

| Lighting Winter Seasonal Peak Hours (90% of 50/50 Peak Forecast)<br><br>Without Occupancy Sensors | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Grocery | 0.77 |
| Manufacturing | 0.43 |
| Medical (Hospital) | 0.62 |
| Office | 0.54 |
| Other | 0.43 |
| Restaurant | 0.64 |
| Retail | 0.65 |
| University/College | 0.53 |
| Warehouse | 0.54 |
| School | 0.38 |
| Total Equal Weight by Sector | 0.55 |

| Lighting Summer Seasonal Peak Hours (90% of 50/50 Peak)<br><br>With Occupancy Sensors | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Manufacturing | 0.20 |
| Medical | 0.24 |
| Office | 0.27 |
| Other | 0.02 |
| University/College | 0.28 |
| Warehouse | 0.25 |
| School | 0.21 |
| Total Equal Weight by Sector | 0.15 |

| Lighting Winter Seasonal Peak Hours (90% of 50/50 Peak)<br><br>With Occupancy Sensors | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Manufacturing | 0.17 |
| Medical | 0.22 |
| Office | 0.30 |
| Other | 0.07 |
| University/College | 0.23 |
| Warehouse | 0.18 |
| School | 0.16 |
| Total Equal Weight by Sector | 0.13 |

***Table 1.1.2 C&I ISO-NE Coincidence Factors***

**Default Commercial and Industrial Peak Coincidence Factors**
**(at meter without line losses)**

Use this Table to determine demand (kW) savings at summer and winter peaks for ISO-NE programs

$$CF\_summer = \frac{kWh\_saved\_during\_all\_1-5\,pm\_time\_periods\_June-Aug}{Number\_of-hours * connected\_load(nameplate\_kW)}$$

$$CF\_winter = \frac{kWh\_saved\_during\_all\_5-7\,pm\_time\_periods\_Dec-Jan}{Number\_of\_hours * connected\_load(nameplate\_kW)}$$

| | **HVAC** | | | | | | |
|---|---|---|---|---|---|---|---|
| | Unitary AC (No chillers) | Variable Frequency Drives | | | Heating | Efficient Motors | |
| | | Pumps | Fans | All | | Cooling | Heating |
| | | Avg of cooling and other | Avg of Air Handler Unit and Cooling tower | | | | |
| Summer | 0.82 | 0.54 | 0.27 | 0.44 | | 0.72 | |
| | | | AHU only | | | | |
| Winter | | 0.48 | 0.48 | 0.42 | * | 0.62 | 0.65 |

* Specific to each measure

| **Lighting Summer On-Peak Hours (1PM-5PM)**<br><br>**Without Occupancy Sensors** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Grocery | 0.95 |
| Manufacturing | 0.73 |
| Medical (Hospital) | 0.77 |
| Office | 0.75 |
| Other | 0.54 |
| Restaurant | 0.81 |
| Retail | 0.82 |
| University/College | 0.68 |
| Warehouse | 0.78 |
| School | 0.63 |
| Total Equal Weight by Sector | 0.75 |

| **Lighting Winter On-Peak Hours (5PM-7PM)**<br><br>**Without Occupancy Sensors** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Grocery | 0.78 |
| Manufacturing | 0.40 |
| Medical (Hospital) | 0.60 |
| Office | 0.54 |
| Other | 0.43 |
| Restaurant | 0.66 |
| Retail | 0.66 |
| University/College | 0.52 |
| Warehouse | 0.50 |
| School | 0.34 |
| Total Equal Weight by Sector | 0.54 |

| **Lighting Summer On-Peak Hours (1PM-5PM)**<br><br>**With Occupancy Sensors** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Manufacturing | 0.21 |
| Medical | 0.23 |
| Office | 0.27 |
| Other | 0.02 |
| University/College | 0.30 |
| Warehouse | 0.27 |
| School | 0.24 |
| Total Equal Weight by Sector | 0.15 |

| **Lighting Winter On-Peak Hours (5PM-7PM)**<br><br>**With Occupancy Sensors** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| Manufacturing | 0.19 |
| Medical | 0.21 |
| Office | 0.31 |
| Other | 0.09 |
| University/College | 0.23 |
| Warehouse | 0.18 |
| School | 0.17 |
| Total Equal Weight by Sector | 0.14 |

***Table 1.1.3 Residential Peak Coincidence Factors (at meter without line losses)***

(Demand (kW) savings for similar end use measures at electrical system peak) / (Connected load from nameplates for the same group of measures)
Use this table to determine demand ( kW) savings at summer and winter peaks

Residential Coincidence Factors at meter ( no line loses)

| End Use >>> | Cooling | Heating | Refrig'n | Water Heating |
|---|---|---|---|---|
| | | | | |
| Summer 3-5PM | Central = 0.75 | | 0.3 | 0.1 |
| | Window = 0.89 | | 0.3 | 0.1 |
| Summer 1-5PM | Central = 0.72 | | | |
| | Window = 0.87 | | | |
| | | | | |
| Winter | 0 | 0.5 | 0.21 | 0.15 |

| **Lighting Summer On-Peak Hours (1PM-5PM)** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| June | 0.07 |
| July | 0.09 |
| August | 0.09 |
| Average Summer | 0.08 |

| **Lighting Winter On-Peak Hours (5PM-7PM)** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| December | 0.28 |
| January | 0.32 |
| Average Winter | 0.30 |

| **Lighting Summer Seasonal Peak Hours (90% of 50/50 Peak Forecast)** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| June | 0.08 |
| July | 0.09 |
| August | 0.10 |
| Average Summer | 0.09 |

| **Lighting Winter Seasonal Peak Hours (90% of 50/50 Peak Forecast)** | |
|---|---|
| **Sector Type** | **Coincidence Factor** |
| December | 0.25 |
| January | 0.28 |
| Average Winter | 0.26 |

**Default Summer & Winter Peak Factors**

| | **Residential Coincident Factors (at meter, no line loss)** | | | | | |
|---|---|---|---|---|---|---|
| | **Cooling** | **Heating** | **Lighting Bulbs** | **Lighting Fixtures** | **Refrigeration** | **Water Heating** |
| **Summer** | 1.700 | 0.0000 | 0.093 | 0.0753 | 0.1368 | 0.0944 |
| **Winter** | 0.0000 | 0.553 | 0.278 | 0.226 | 0.0979 | 0.1389 |

**Use of residential default peak factors**
Residential default peak factors can be used to calculate summer and winter demand savings based on the annual savings (kWh) of a measure. The units for these peak factors are Watts/Annual kWh savings where "Watts" is the winter or summer demand savings of the measure. For instance, if a residential lighting measure has an annual savings of 100 kWh, the peak summer demand savings is calculated as follows:

**Summer Demand Savings =** annual savings (kWh) x residential peak summer factor (lighting)

= 100 kWh x 0.0788 Watt/kWh = 7.88 watts = **0.00788 kW.**

Residential default peak factors should be used only when actual summer or winter demand savings is unknown for the measure. The peak factors shown were derived from CL&P load research data and can be used to estimate the demand reduction resulting from implementation of a conservation program with a large number of specific measures, many of which are expected to be in operation during peak demand periods.

## 7.1.2 TABLE 1.2 LOAD SHAPES

**Table 1.2: Load Shapes by end use and sector.**

| Load Shape | Winter Peak Energy % | Winter Off-Peak Energy % | Summer Peak Energy % | Summer Off-Peak Energy % |
|---|---|---|---|---|
| **End Use** | **Residential** | | | |
| Cooling | 5.0% | 5.0% | 65.0% | 25.0% |
| Heating | 55.0% | 30.0% | 5.0% | 10.0% |
| Lighting | 30.0% | 40.0% | 10.0% | 20.0% |
| Refrigeration | 30.0% | 30.0% | 20.0% | 20.0% |
| Water Heating | 30.0% | 30.0% | 20.0% | 20.0% |
| | **Commercial & Industrial** | | | |
| Cooling | 3.0% | 2.0% | 80.0% | 15.0% |
| Heating | 60.0% | 35.0% | 5.0% | 0.0% |
| Lighting | 50.0% | 10.0% | 30.0% | 10.0% |
| Refrigeration | 30.0% | 30.0% | 20.0% | 20.0% |
| Other | 50.0% | 10.0% | 30.0% | 10.0% |
| Motors | 50.0% | 10.0% | 30.0% | 10.0% |
| Process | 50.0% | 10.0% | 30.0% | 10.0% |

Winter is defined as October – May
Summer is defined as June – September
Peak is defined as 6:00 AM – 11:00 PM weekdays (no holidays)
Off-peak is defined 11:00 PM to 6:00 AM, plus all weekend and holiday hours.

## 7.1.3 TABLE 1.3 REALIZATION RATES

**Table 1.3A: C & I Realization Rates – CL&P**

**Commercial and Industrial Realization Rates used in CL&P Programs**

| Program | End-use | Gross Realization | Free-ridership | Spillover | **Net Realization** |
|---|---|---|---|---|---|
| EO | Cooling | 88.4 % | 7.1 % | 1.6 % | **83.5 %** |
| EO | Heating | 88.4 % | 7.1 % | 1.6 % | **83.5 %** |
| EO | Lighting | 97.4 % | 1.4 % | 9.8 % | **105.7 %** |
| EO | Other | 75.8 % | 24.7 % | 0.6 % | **57.5 %** |
| EO | Process | 101.5 % | 24.7 % | 0.6 % | **77.0 %** |
| EO | Refrigeration | 75.8 % | 24.7 % | 0.6 % | **57.5 %** |
| ECB | Cooling | 97.8 % | 20.3 % | 0.5 % | **78.5 %** |
| ECB | Heating | 117.7 % | 27.4 % | 0.1 % | **85.5 %** |
| ECB | Lighting | 112.3 % | 5.0 % | 0.9 % | **107.7 %** |
| ECB | Other | 83.9 % | 24.4 % | 0.9 % | **64.2 %** |
| ECB | Process | 100.9 % | 24.7 % | 0.6 % | **76.6 %** |
| ECB | Refrigeration | 68.1 % | 24.6 % | 1.0 % | **52.0 %** |
| ECB | PRIME | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| SBEA | Cooling | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| SBEA | Heating | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| SBEA | Lighting | 98.5 % | 0.5 % | 10.9 % | **108.7%** |
| SBEA | Other | 100.0 % | 16.6 % | 0.0 % | **83.4 %** |
| SBEA | Refrigeration | 100.0 % | 16.6 % | 0.0 % | **83.4 %** |
| O & M | Cooling | 88.2 % | 12.1 % | 0.0 % | **77.5 %** |
| O & M | Heating | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| O & M | Other | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| O & M | Process | 81.8 % | 3.1 % | 0.0 % | **79.3 %** |
| DR | All | 61.0 % | 0.0 % | 0.0 % | **61.0 %** |
| LR | All | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| PF | All | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |
| RC | All | 100.0 % | 0.0 % | 0.0 % | **100.0 %** |

*Note: The above is used for energy (kWh) as well as demand (kW) with the exception of Demand Reduction (DR). For DR the demand Realization rate is 43%.

References:

Northeast Utilities Impact Evaluation of the Demand Reduction Program,

Northeast Utilities Custom Services Impact Evaluation 2004 Measure Installations
-RLW Analytics, Inc., Final Report March 2006

Connecticut Utilities 2003 Small Business Energy Advantage Program Impact Evaluation
-RLW Analytics, Inc., Final Report June 2004

Northeast Utilities New Construction Impact Evaluation 2000 Measure Installations
-RLW Analytics, Inc., Final Report December 2002

Northeast Utilities 1999 Express Services Program Impact Evaluation
-PA Consulting Group, Final Report June 2001

Northeast Utilities 1999 O & M Services Program Impact and Process Evaluation
-RLW Analytics, Inc., Final Report October 2001

* Gross realization rates for ECC Other, O&M Other and O&M Heating were reduced to 100.0%

**Table 1.3B: C & I Realization Rates - UI**

**Commercial and Industrial Realization Rates used in UI Programs**

| Program | End Use | Gross Realization % | Free Ridership % | Spillover % | **Net Realization** |
|---|---|---|---|---|---|
| ECB | Lighting | 112.3 | 31.9 | 0.3 | **76.8%** |
| | Motors | 83.9 | 34.24 | 10.12 | **63.7%** |
| | Cooling | 97.8 | 10.47 | 0 | **87.6%** |
| | Custom, Process & Other | 92.4 | 14.1 | 2.3 | **81.5%** |
| | VFD's | 83.9 | 32.7 | 5.4 | **61.0** |
| EO | Lighting | 97.4 | 0.7 | 0 | **96.7%** |
| | Custom | 75.8 | 14.9 | 18.9 | **78.8%** |
| | Other | 75.8 | 0 | 0 | **75.8%** |
| SBEA | Lighting | 100 | 0.5 | 0.3 | **99.8%** |
| | Refrigeration | 100 | 0 | 0 | **100.0%** |

**Notes**

Net Annual Measure Savings = (Gross Annual Savings) X (Net Realization %)

Net Realization = (Gross Realization) % X (100% - Free-Ridership % + Spillover %)

**References**

**Energy Conscious Construction**

2004 C&I Free Ridership & Spillover Study
UI's Net-to-Gross Rates by Pgm & Measure Group, Pg 196
Megdal Associates & Opinion Dynamics Corp. March 2006

UI 2005 C&I Pgms Free-Ridership & Spillover Study Draft Exe. Summary 5-31-06, Table 1, Pg 4
PA Knowledge Limited May 31, 2006

NU Cust. Services New Construction Impact Eval. 2000 Measure Installation Table Ex 3 Pg 4
RLW Analytics Final Report Dec. 2002
Custom, Process and Other are the average of CL&P's Other and Process for ECB

**Energy Opportunities**

2004 C&I Free Ridership & Spillover Study
Table 10.2 UI's Net-to-Gross Rates by Pgm & Measure Group, Pg 196
Megdal Associates & Opinion Dynamics Corp., March 2006

NU Custom services Impact Evaluation 2004 Measure Installations, Table Ex1 Pg 1
RLW Analytics Final Report March 2006

NU 1999 Express Services Program Impact Evaluation Table 1-4 Page 1-3
PA Consulting Group, Final Report, June 2001

**Small Business**

CT Utilities Sm Bus Energy Adv. Program Impact Evaluation Final Report Table 15, Pg 18
RLW Analytics, June 2004

**Table 1.3C: Residential Realization Rates – CL&P and UI**

**Residential Realization Rates used in the listed CL&P and UI Programs**

| | Program | Free-ridership | Spillover | Breakage | Installation Rate | **Net Realization Rate** |
|---|---|---|---|---|---|---|
| 5.3.1 | CFL Bulbs | 6% | 15% | | 70% | **76%** |
| 5.3.2 | Portable Lamps | 3% | 6% | | 70% | **72%** |
| 5.3.3 | Torchiere | 3% | 6% | | 70% | **72%** |
| 5.3.4 | Fixture (Hard Wired) | 3% | 6% | | 80% | **82%** |
| 5.3.5 | Ceiling Fan & Lights | 3% | 6% | | 80% | **82%** |
| 5.3.7 | Clothes Washer (Retail) | | | | | **20%** |
| 5.3.8 | Dishwasher (Retail) | | | | | **20%** |
| 5.3.9 | Refrigerator (Retail) | | | | | **20%** |
| 5.3.14 | Dehumidifier (Retail) | | | | | **20%** |
| 5.3.10 | AC Turn-in (old unit) | | | | | **20.7%** |
| 5.3.10 | AC New (w/ turn-in) | | | | | **26.0%** |

# 7.1.4 TABLE 1.4 LIFETIMES

**Table 1.4 Lifetimes**
**Commercial and Industrial Measures**

| | SBEA | Retrofit | New Construction |
|---|---|---|---|
| **Lighting Systems, including:** | | | |
| Lighting system | 13 | 13 | 15 |
| Fluorescent Fixtures | 13 | 13 | 15 |
| Hard-Wired Compact (PL)Fluorescent Fixtures | 13 | 13 | 15 |
| High Intensity Discharge Fixtures | 13 | 13 | 15 |
| Low-Voltage Tungsten Halogen Fixtures | 13 | 13 | 15 |
| Electronic Ballasts | 13 | 13 | N/A |
| Occupancy Sensors | 9 | 9 | 10 |
| Automatic Photocell Dimming Systems | 9 | 9 | 10 |
| Sweep Controls | 10 | 10 | 15 |
| Pulse Start HID Retrofit | 13 | 13 | 15 |
| **Building Envelope** | | | |
| Roof Insulation | 25 | 25 | 25 |
| Wall Insulation | 25 | 25 | 25 |
| Window Film | 10 | 10 | 10 |
| New Windows | 20 | 20 | 20 |
| Movable Window Insulation | 10 | 10 | 10 |
| Roof Spray Cooling | 15 | 15 | 15 |
| Plenum/Attic Insulation | 14 | 14 | 14 |
| **Domestic Hot Water** | | | |
| Heat Pump Water Heater | 12 | 12 | 12 |
| Point-of-Use Water Heater | 12 | 12 | 12 |
| Solar Water Heater | 20 | 20 | 20 |
| Heat Recovery | 15 | 15 | 15 |
| Controls (EMS) | 15 | 15 | 15 |
| **Heating, Ventilating and Air Conditioning (HVAC) Systems** | | | |
| Energy-Efficient Motors | 15 | 15 | 20 |
| Chiller Strainer Cycle System | | | 20 |
| High-Efficiency Unitary Air Conditioners | 13 | 13 | 15 |
| High-Efficiency Split-System Air Conditioners | 13 | 13 | 15 |
| 2-Speed Motor Control in Rooftop Units | 15 | 15 | 20 |
| Energy-Efficient Packaged Terminal Units | 13 | 13 | 15 |
| Air-to-Air Heat Pump | 13 | 13 | 15 |
| Water-to-Air Heat Pump | 13 | 13 | 15 |
| Dehumidifiers | 13 | 13 | 15 |
| Heat Pump Variable Speed Drive | 13 | 13 | 15 |
| **Chillers** | | | |
| Water Cooled | 17 | 17 | 23 |
| Air Cooled | 17 | 17 | 23 |
| **Variable Frequency Chiller Drive** | | | |
| New | | | 20 |
| Added to Existing Chiller | 13 | 13 | |
| Cool Thermal Storage | 15 | 15 | 15 |

| | SBEA | Retrofit | New Construction |
|---|---|---|---|
| Evaporative Cooling | 13 | 13 | 15 |
| Plate/Heat Pipe Type Heat Recovery System | 18 | 18 | 18 |
| Rotary Type Heat Recovery System | 14 | 14 | 14 |
| Heat Recovery from Refrigeration System | 10 | 10 | 15 |
| Enthalpy Control Economizer | 7 | 7 | 10 |
| Economizer-Air/Water | 10 | 10 | 15 |
| Low-Leakage Damper | 12 | 12 | 12 |
| VAV Variable Speed Drive | 13 | 13 | 15 |
| VAV System Components | 13 | 13 | 15 |
| Induced Draft Cooling Towers | 13 | 13 | 15 |
| Variable Pitch Fan for Cooling Tower | 13 | 13 | 15 |
| Cooling Tower Fan Pony Motor | 13 | 13 | 15 |
| Variable Frequency Pump Drive (Solid State) | 13 | 13 | 15 |
| Zoned Circulator Pump System | 15 | 15 | 15 |
| Make-up Air Unit for Exhaust Hood | 15 | 15 | 15 |
| Pipe and Duct Systems | 20 | 20 | 20 |
| Paddle Type Air Destratification Fan | 10 | 10 | 10 |
| Duct Type Air Destratification System Air Curtain | 15 | 15 | 15 |
| Electric Spot Radiant Heat | 10 | 10 | 10 |
| **Controls** | | | |
| Automatic Energy Management Controls | 10 | 10 | 15 |
| Occupancy Sensor Ventilation Control | 10 | 10 | 15 |
| Variable Inlet Vane Control | 10 | 10 | 15 |
| Time Clock | 10 | 10 | 10 |
| **Refrigeration** | | | |
| **New Central Compressor Refrigeration Systems and Components** | | | |
| Air Cooled | 20 | 20 | 20 |
| Water Cooled | 20 | 20 | 20 |
| **Refrigeration Compressor Systems, including:** | | | |
| Screw Compressors | 20 | 20 | 20 |
| Open Drive Compressors | 20 | 20 | 20 |
| Hermetic Compressors | 20 | 20 | 20 |
| Semihermetic Compressors | 20 | 20 | 20 |
| Compressor Capacity Control | 10 | 10 | 10 |
| Condenser Floating Head Pressure Control | 10 | 10 | 10 |
| Mechanical Subcooling | 15 | 15 | 15 |
| Ambient Subcooling | 15 | 15 | 15 |
| Auto Cleaning System for Condenser Tubes | 10 | 10 | 10 |
| Hot Gas Bypass Defrost | 10 | 10 | 10 |
| Defrost Control Optimization | 10 | 10 | 10 |
| Proportional Anti-Condensate Heater Controls | 10 | 10 | 10 |
| Open or Enclosed Display Cases | 10 | 10 | 10 |
| Case Cover | 10 | 10 | 10 |
| Polyethylene Strip Curtai | 3 | 3 | 3 |
| Automatic Door Closers and Controls | 10 | 10 | 10 |
| Vertical Dock Levelers | 15 | 15 | 15 |
| High-Low Freezer/Cooler Dimmers | 10 | 10 | 10 |
| Oversized Condensers | 15 | 15 | 15 |

| | SBEA | Retrofit | New Construction |
|---|---|---|---|
| Low Case HVAC Returns | 10 | 10 | 10 |
| Demineralized Water for Ice | 10 | 10 | 10 |
| Low Emissivity Ceiling Surface | 15 | 15 | 15 |
| Ice Temp Sensor | 10 | 10 | 10 |
| Hot Gas Regeneration | 10 | 10 | 10 |
| Evaporator Controls | 10 | 10 | 10 |
| **Process Equipment** | | | |
| Air Compressor | 13 | 13 | 15 |
| Refrigerated Air Dryer | 13 | 13 | 15 |
| Variable Frequency Drives | 13 | 13 | 15 |

**Residential Program Measure Lives**

| | Life in years |
|---|---|
| **Energy Star Homes** | |
| CFL Bulbs | |
| Rated hours | |
| 6,000 | 5 |
| 7,000 | 6 |
| 8,000 | 7 |
| 10,000 | 8 |
| 12,000 | 10 |
| 15,000 | 13 |
| CFL Interior Fixtures (Hardwired) | 20 |
| CFL Exterior Fixtures (Hardwired) | 15 |
| | |
| **Residential HVAC** | |
| Central Air Systems | 18 |
| Air Source Heat Pumps | 18 |
| Geothermal Heat Pumps | 18 |
| Commissioning for AC Systems | 18 |
| Commisioning for Air Source Heat Pumps | 18 |
| Commisioning for Geothermal Heat Pumps | 18 |
| AC System Tune-up | 5 |
| Electronically Commutated Motor | 18 |
| Duct Sealing (Retrofit) | 20 |
| Duct blaster Test (New Construction) | 25 |
| | |
| **Residential Products and Services** | |
| CFL Bulbs | |
| Rated hours | Life in years |
| 6000 | 5 |
| 7000 | 6 |
| 8000 | 7 |
| 10000 | 8 |
| 12000 | 10 |
| 15000 | 13 |
| Portable Lamps | 8 |
| Torchiere | 8 |

| | Life in years |
|---|---|
| CFL Interior Fixtures (Hardwired) | 20 |
| CFL Exterior Fixtures (Hardwired) | 15 |
| Ceiling Fan with CFL Lights | 20 |
| Room AC Units | 12 |
| Clothes Washers | 14 |
| Dish Washers | 12 |
| Refrigerators | 20 |
| Dehumidifiers | 12 |
| | |
| **Residential Envelope Measures** | |
| REM Savings (for Energy Star Homes) | |
| Heating | 25 |
| Cooling | 25 |
| Dom. Water Heating | 25 |
| BOP (Builder Option Plan for Energy Star homes) | |
| Heating | 25 |
| Cooling | 25 |
| Dom. Water Heating | 25 |
| Blower Door Test | 25 |
| High Performance Wall Insulation | 25 |
| High Performance Ceiling Insulation | 25 |
| | |
| **Low Income Program Measures** | |
| CFL Bulbs | |
| Rated hours | Life in years |
| 6,000 | 5 |
| 7,000 | 6 |
| 8,000 | 7 |
| 10,000 | 8 |
| 12,000 | 10 |
| 15,000 | 13 |
| Outdoor Fixtures (Hard-wired) | 15 |
| Indoor Fixtures (Hard-wired) | 20 |
| Portable lamps | 8 |
| Torchiere | 8 |
| Outdoor Security Lighing | 15 |
| | |
| **Low Income Program HVAC** | |
| Duct Insulation | 20 |
| Duct Sealing | 20 |
| Pipe Insulation | 15 |
| HVAC Custom Measures | |
| Existing Equipmment (Heating, Central Air or Heat Pumps) | 5 |
| New Equipment | 18 |
| Window or Sleeve Room AC Units | 12 |
| Room AC Units | 12 |
| **Low Income Products and Services** | |
| Domestic Water Heater Thermostat Setting ( Existing Unit) | 4 |

| | Life in years |
|---|---|
| Low Flow Shower Head | 5 |
| Water Heater Wrap (Existing Unit) | 5 |
| Faucet Aerator | 5 |
| Flip Aerator | 5 |
| Refrigerator Replacement | 10 |
| Freezer Replacement | 10 |
| | |
| **Low Income Program Envelope Measures** | |
| Electrical Outlet Gaskets | 15 |
| Door Sweep | 5 |
| Door Sealing Kit | 5 |
| Air Leak Caulking and Sealing | 10 |
| Air leak Sealing with Polyethylene Tape | 10 |
| Weatherstripping of Windows | 5 |
| Weatherstripping of Doors | 5 |
| Insulating Attic Hatchway | 25 |
| Broken Window Repair | 5 |
| Storm Window Installation | 20 |
| Install Ceiling Insulation | 25 |
| Install Wall Insulation | 25 |
| Blower Door Test | 20 |
| Custom Weatherization Default life | 20 |

## 7.2.0 TABLE 2.0.0 C&I HOURS

**Table 2.0.0: C&I Hours of Use and EFLH**

| Facility Type | Lighting Hours | Cooling FLHrs | Heating FLHrs | Fan Motor Hours | CHWP & Cooling Towers | Heating Pumps |
|---|---|---|---|---|---|---|
| Auto Related | 4,056 | 837 | 1,171 | 4,056 | 1,878 | 6,000 |
| Bakery | 2,854 | 681 | 1,471 | 2,854 | 1,445 | 6,000 |
| Banks, Financial Centers | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Church | 1,955 | 564 | 1,694 | 1,955 | 1,121 | 6,000 |
| College - Cafeteria | 6,376 | 1,139 | 594 | 6,376 | 2,713 | 6,000 |
| College - Classes/Administrative | 2,586 | 646 | 1,537 | 2,586 | 1,348 | 6,000 |
| College - Dormitory | 3,066 | 709 | 1,418 | 3,066 | 1,521 | 6,000 |
| Commercial Condos | 4,055 | 837 | 1,172 | 4,055 | 1,877 | 6,000 |
| Convenience Stores | 6,376 | 1,139 | 594 | 6,376 | 2,713 | 6,000 |
| Convention Center | 1,954 | 564 | 1,695 | 1,954 | 1,121 | 6,000 |
| Court House | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Dining: Bar Lounge/Leisure | 4,182 | 854 | 1,140 | 4,182 | 1,923 | 6,000 |
| Dining: Cafeteria / Fast Food | 6,456 | 1,149 | 574 | 6,456 | 2,742 | 6,000 |
| Dining: Family | 4,182 | 854 | 1,140 | 4,182 | 1,923 | 6,000 |
| Entertainment | 1,952 | 564 | 1,695 | 1,952 | 1,120 | 6,000 |
| Exercise Center | 5,836 | 1,069 | 728 | 5,836 | 2,518 | 6,000 |
| Fast Food Restaurants | 6,376 | 1,139 | 594 | 6,376 | 2,713 | 6,000 |
| Fire Station (Unmanned) | 1,953 | 564 | 1,695 | 1,953 | 1,121 | 6,000 |
| Food Stores | 4,055 | 837 | 1,172 | 4,055 | 1,877 | 6,000 |
| Gymnasium | 2,586 | 646 | 1,537 | 2,586 | 1,348 | 6,000 |
| Hospitals | 7,674 | 1,308 | 270 | 7,674 | 3,180 | 6,000 |
| Hospitals / Health Care | 7,666 | 1,307 | 272 | 7,666 | 3,177 | 6,000 |
| Industrial - 1 Shift | 2,857 | 681 | 1,470 | 2,857 | 1,446 | 6,000 |
| Industrial - 2 Shift | 4,730 | 925 | 1,003 | 4,730 | 2,120 | 6,000 |
| Industrial - 3 Shift | 6,631 | 1,172 | 530 | 6,631 | 2,805 | 6,000 |
| Laundromats | 4,056 | 837 | 1,171 | 4,056 | 1,878 | 6,000 |
| Library | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Light Manufacturers | 2,857 | 681 | 1,470 | 2,857 | 1,446 | 6,000 |
| Lodging (Hotels/Motels) | 3,064 | 708 | 1,418 | 3,064 | 1,521 | 6,000 |
| Mall Concourse | 4,833 | 938 | 978 | 4,833 | 2,157 | 6,000 |
| Manufacturing Facility | 2,857 | 681 | 1,470 | 2,857 | 1,446 | 6,000 |
| Medical Offices | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Motion Picture Theatre | 1,954 | 564 | 1,695 | 1,954 | 1,121 | 6,000 |
| Multi-Family (Common Areas) | 7,665 | 1,306 | 273 | 7,665 | 3,177 | 6,000 |
| Museum | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Nursing Homes | 5,840 | 1,069 | 727 | 5,840 | 2,520 | 6,000 |
| Office (General Office Types) | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Office/Retail | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Parking Garages & Lots | 4,368 | 878 | 1,094 | 4,368 | 1,990 | 6,000 |
| Penitentiary | 5,477 | 1,022 | 817 | 5,477 | 2,389 | 6,000 |
| Performing Arts Theatre | 2,586 | 646 | 1,537 | 2,586 | 1,348 | 6,000 |

| Facility Type | Lighting Hours | Cooling FLHrs | Heating FLHrs | Fan Motor Hours | CHWP & Cooling Towers | Heating Pumps |
|---|---|---|---|---|---|---|
| Police / Fire Stations (24 Hr) | 7,665 | 1,306 | 273 | 7,665 | 3,177 | 6,000 |
| Post Office | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Pump Stations | 1,949 | 563 | 1,696 | 1,949 | 1,119 | 6,000 |
| Refrigerated Warehouse | 2,602 | 648 | 1,533 | 2,602 | 1,354 | 6,000 |
| Religious Building | 1,955 | 564 | 1,694 | 1,955 | 1,121 | 6,000 |
| Residential (Except Nursing Homes) | 3,066 | 709 | 1,418 | 3,066 | 1,521 | 6,000 |
| Restaurants | 4,182 | 854 | 1,140 | 4,182 | 1,923 | 6,000 |
| Retail | 4,057 | 837 | 1,171 | 4,057 | 1,878 | 6,000 |
| School / University | 2,187 | 594 | 1,637 | 2,187 | 1,205 | 6,000 |
| Schools (Jr./Sr. High) | 2,187 | 594 | 1,637 | 2,187 | 1,205 | 6,000 |
| Schools (Preschool/Elementary) | 2,187 | 594 | 1,637 | 2,187 | 1,205 | 6,000 |
| Schools (Technical/Vocational) | 2,187 | 594 | 1,637 | 2,187 | 1,205 | 6,000 |
| Small Services | 3,750 | 798 | 1,247 | 3,750 | 1,768 | 6,000 |
| Sports Arena | 1,954 | 564 | 1,695 | 1,954 | 1,121 | 6,000 |
| Town Hall | 3,748 | 797 | 1,248 | 3,748 | 1,767 | 6,000 |
| Transportation | 6,456 | 1,149 | 574 | 6,456 | 2,742 | 6,000 |
| Warehouse (Not Refrigerated) | 2,602 | 648 | 1,533 | 2,602 | 1,354 | 6,000 |
| Waste Water Treatment Plant | 6,631 | 1,172 | 530 | 6,631 | 2,805 | 6,000 |
| Workshop | 3,750 | 798 | 1,247 | 3,750 | 1,768 | 6,000 |

## 7.2.1 TABLE 2.1.1B EMERGING LIGHTING TECHNOLOGIES

**Table 2.1.1.B: Emerging Technology Lighting Fixtures**

| Fixture Type |
| --- |
| Ceramic Metal Halide |
| Super T8 Lamp and Ballast Combination |
| Induction |
| Low wattage MH |
| LED for interior lighting |

## 7.2.2 TABLE 2.1.1C BLDG AREA LIGHT POWER

**Table 2.1.1.C: Building Area Lighting Power Densities**

| Ashrae TABLE 9.3.1.1<br>Lighting Power Densities Using<br>the Building Area Method | |
|---|---|
| Building Area Type<br>(see note) | Lighting Power Density<br>(W/ft2) |
| 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/Healthcare | 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 |

Note: In cases where both general building area type and a specific building area type are listed, the specific building area type shall apply.

## 7.2.3 TABLE 2.1.1D SPACE-BY-SPACE LIGHT POWER

**Table 2.1.1.D: Space-by-Space Lighting Power Densities**

| Ashrae TABLE 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method | | | |
|---|---|---|---|
| Space-by-Space Method Lighting Power Density (LPD) | | | |
| Common Space Types (See Note a) | LPD (W/ft2) | Building-Specific Space Types | LPD (W/ft2) |
| Office-enclosed | 1.1 | Gymnasium/ Exercise Center | |
| Office-open plan | 1.1 | Playing Area | 1.4 |
| Conference/ Meeting/ Multipurpose | 1.3 | Exercise Area | 0.9 |
| Classroom/ Lecture/ Training | 1.4 | Courthouse/ Police Station/ Penitentiary | |
| for Penitentiary | 1.3 | Courtroom | 1.9 |
| Lobby | 1.3 | Confinement Cells | 0.9 |
| for Hotel | 1.1 | Judges' Chambers | 1.3 |
| for Performing Arts Theater | 3.3 | Fire Stations | |
| for Motion Picture Theatre | 1.1 | Fire Station Engine room | 0.8 |
| Audience/ Seating Area | 0.9 | Sleeping Quarters | 0.3 |
| for Gymnasium | 0.4 | Post Office - Sorting Area | 1.2 |
| for Exercise Center | 0.3 | Convention Center - Exhibit Space | 1.3 |
| for Convention Center | 0.7 | Library | |
| for Penitentiary | 0.7 | Card File & Cataloguing | 1.1 |
| for Religious Buildings | 1.7 | Stacks | 1.7 |
| for Sports Arena | 0.4 | Reading Area | 1.2 |
| for Performing Arts Theatre | 2.6 | Hospital | |
| for Motion Picture theatre | 1.2 | Emergency | 2.7 |
| for Transportation | 0.5 | Recovery | 0.8 |
| Atrium-first three floors | 0.6 | Nurse station | 1.0 |
| Atrium-each additional floor | 0.2 | Exam/Treatment | 1.5 |
| Lounge/Recreation | 1.2 | Pharmacy | 1.2 |
| for Hospital | 0.8 | Patient Room | 0.7 |
| Dining area | 0.9 | Operating Room | 2.2 |
| for Penitentiary | 1.3 | Nursery | 0.6 |
| for Hotel | 1.3 | Medical Supply | 1.4 |
| for Motel | 1.2 | Physical Therapy | 0.9 |
| for Bar Lounge/Leisure Dining | 1.4 | Radiology | 0.4 |
| for Family Dining | 2.1 | Laundry-Washing | 0.6 |
| Food Preparation | 1.2 | Automotive – Service/Repair | 0.7 |
| Laboratory | 1.4 | Manufacturing | |
| Restrooms | 0.9 | Low Bay (<25 ft Floor to Ceiling Height) | 1.2 |
| Dressing/Locker/Fitting Room | 0.6 | High Bay (>25 ft Floor to Ceiling Height) | 1.7 |
| Corridor/Transition | 0.5 | Detailed Manufacturing | 2.1 |
| for Hospital | 1.0 | Equipment room | 1.2 |
| for Manufacturing Facility | 0.5 | Control room | 0.5 |
| Stairs – active | 0.6 | Hotel/ Motel Guest Rooms | 1.1 |
| Active Storage | 0.8 | Dormitory - Living Quarters | 1.1 |

| Ashrae TABLE 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method | | | |
|---|---|---|---|
| Space-by-Space Method Lighting Power Density (LPD) | | | |
| Common Space Types (See Note a) | LPD (W/ft2) | Building-Specific Space Types | LPD (W/ft2) |
| for Hospital | 0.9 | Museum | |
| Inactive storage | 0.3 | General Exhibition | 1.0 |
| for Museum | 0.8 | Restoration | 1.7 |
| Electrical/ mechanical | 1.5 | Bank/Office - Banking Activity Area | 1.5 |
| Workshop | 1.9 | Religious Buildings | |
| | | Worship-pulpit, choir | 2.4 |
| | | Fellowship Hall | 0.9 |
| | | Retail [For accent lighting see 9.3.1.2.1.(c)] | |
| | | Sales area | 1.7 |
| | | Mall Concourse | 1.7 |
| | | Sports Arena | |
| | | Ring Sports Area | 2.7 |
| | | Court Sports Area | 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 |
| | | Air/Train/Bus - Baggage Area | 1.0 |
| | | Terminal - Ticket counter | 1.5 |
| | | | |
| Note a: In cases where both a common space type and a building specific space type are listed, the building-specific space type shall apply. | | | |

## 7.2.4 TABLE 2.2.1A CHILLER EFFICIENCIES

**Table 2.2.1.A: Chiller Baseline and Compliance Efficiencies**

| **Water-cooled Centrifugal** | | | **Water-Cooled Screw & Scroll** | | | **Air-Cooled** | | |
|---|---|---|---|---|---|---|---|---|
| | Maximum IPLV, kW/ton | | | Maximum IPLV, kW/ton | | | Maximum IPLV, EER | |
| Tons less than | Baseline | Compliance | Tons less than | Baseline | Compliance | Tons | Baseline | Compliance |
| <100 | 0.67 | 0.610 | <100 | 0.677 | 0.640 | <100 | 10.41 | 12.1 |
| 125 | 0.67 | 0.610 | 125 | 0.677 | 0.620 | 100 | 10.41 | 12.010 |
| 150 | 0.60 | 0.570 | 150 | 0.677 | 0.610 | 111 | 10.41 | 11.910 |
| 175 | 0.60 | 0.570 | 175 | 0.633 | 0.590 | 121 | 10.41 | 11.810 |
| 200 | 0.60 | 0.570 | 200 | 0.633 | 0.570 | 131 | 10.41 | 11.710 |
| 225 | 0.60 | 0.570 | 225 | 0.633 | 0.540 | 141 | 10.41 | 11.610 |
| 250 | 0.60 | 0.570 | 250 | 0.633 | 0.540 | 151 | 10.41 | 11.510 |
| 275 | 0.60 | 0.570 | 275 | 0.633 | 0.540 | 161 | 10.41 | 11.510 |
| 300 | 0.60 | 0.530 | 300 | 0.633 | 0.540 | 171 | 10.41 | 11.410 |
| 300 and over | 0.55 | 0.530 | 325 | 0.573 | 0.540 | 181 | 10.41 | 11.310 |
| | | | 350 | 0.573 | 0.530 | 191 | 10.41 | 11.210 |
| | | | 375 | 0.573 | 0.530 | 201 | 10.41 | 11.110 |
| | | | 400 | 0.573 | 0.530 | 211 | 10.41 | 11.010 |
| | | | 425 | 0.573 | 0.530 | 221 | 10.41 | 10.910 |
| | | | 450 | 0.573 | 0.530 | 231 | 10.41 | 10.810 |
| | | | 475 | 0.573 | 0.530 | 241 | 10.41 | 10.710 |
| | | | 500 | 0.573 | 0.530 | 251 | 10.41 | 10.610 |
| | | | 525 | 0.573 | 0.520 | 261 | 10.41 | 10.510 |
| | | | 550 | 0.573 | 0.520 | 271 | 10.41 | 10.410 |
| | | | 575 | 0.573 | 0.520 | 281 | 10.41 | 10.310 |
| | | | 600 | 0.573 | 0.520 | 291 | 10.41 | 10.310 |
| | | | 625 | 0.573 | 0.510 | 301 | 10.41 | 10.210 |
| | | | 650 and over | 0.573 | 0.510 | 311 | 10.41 | 10.110 |
| | | | | | | 321 | 10.41 | 10.010 |
| | | | | | | 331 and over | 10.41 | 9.910 |

Rev 5, 8-3-07

## 7.2.5 TABLE 2.2.1B CHILLER RATING CONDITIONS

**Table 2.2.1.B: Chiller ARI Rating Conditions**

| CHILLER RATINGS | | | |
|---|---|---|---|
| TABLE 3. - ENTERING CONDENSER FLUID TEMPERATURES AT PART LOAD I-P SYSTEM | | | |
| % LOAD | 1998 STANDARD | | |
| | WC<br>˚F ECWT | AC<br>˚F EDB | EC<br>˚F EWB |
| 100% | 85 | 95 | 75 |
| 75% | 75 | 80 | 68.75 |
| 50% | 65 | 65 | 62.5 |
| 25% | 65 | 55 | 56.25 |

WC = water-cooled ECWT = entering condenser water temperature
AC = air-cooled EDB = entering air dry bulb temperature
EC = evaporative cooled EWB = entering air wet bulb temperature

Table 6. ARI Standard 550/590-98 is reprinted below to show the ARI Standard Rating Condition. This chart is reprinted with permission from ARI:

| CHILLER RATINGS | | | |
|---|---|---|---|
| TABLE 6. STANDARD RATING CONDITIONS | | | |
| | Water-Cooled | Evaporatively-Cooled | Air-Cooled |
| CONDENSER WATER | | | |
| Entering | 85˚F | | |
| Flow Rate | 3.0 gpm/ton | | |
| CONDENSER FOULING FACTOR ALLOWANCE | | | |
| Water Side | 0.00025 h ft $^2$ ˚ F/Btu | | |
| Air-Side | | 0 h ft$^2$ ˚F/Btu | 0 h ft$^2$ ˚F/Btu |
| ENTERING AIR | | | |
| Dry Bulb | | | 95˚F |
| Wet Bulb | | 75˚F | |
| EVAPORATOR WATER | | | |
| Leaving | 44˚F | | |
| Flow Rate | 2.4 gpm/ton | | |
| EVAPORATOR FOULING FACTOR ALLOWANCE | | | |
| Water-Side | 0.0001 h ft$^2$ ˚F/Btu | | |
| Refrigerant-Side | 0 h ft$^2$ ˚F/Btu | | |
| CONDENSERLESS | | | |
| | | Water or Evaporatively Cooled | Air-Cooled |
| Saturated Discharge | | 105˚F | 125˚F |
| Liquid Refrigerant | | 98˚F | 105˚F |
| Barometric Pressure - 29.92 in. of Hg | | | |

## 7.2.6 TABLE 2.2.1C CHILLER PART-LOAD EFFICIENCIES

**Table 2.2.1.C: Chiller Part-Load Efficiencies**

Water-Cooled Centrifugal

| Load | <150 Tons kW/Ton | >=150 Tons &<300 Tons kW/Ton | >=300 Tons kW/Ton |
|---|---|---|---|
| 100% | 0.703 | 0.630 | 0.580 |
| 75% | 0.635 | 0.571 | 0.524 |
| 50% | 0.673 | 0.602 | 0.549 |
| 25% | 0.807 | 0.717 | 0.666 |
| IPLV | 0.670 | 0.600 | 0.550 |

Air-Cooled

| Load | <150 Tons EER | >=150 Tons EER |
|---|---|---|
| 100% | 9.560 | 9.560 |
| 75% | 10.349 | 10.349 |
| 50% | 10.894 | 10.894 |
| 25% | 8.879 | 8.879 |
| IPLV | 10.410 | 10.410 |

Water-Cooled Screw & Scroll

| Load | <150 Tons kW/Ton | >=150 Tons &<300 Tons kW/Ton | >=300 Tons kW/Ton |
|---|---|---|---|
| 100% | 0.790 | 0.718 | 0.639 |
| 75% | 0.642 | 0.601 | 0.546 |
| 50% | 0.679 | 0.634 | 0.571 |
| 25% | 0.815 | 0.756 | 0.693 |
| IPLV | 0.677 | 0.633 | 0.573 |

## 7.2.7 TABLE 2.3 COOLING EFFIENCIES REQUIRED

Table 2.3

The baseline efficiencies are the same as required by the Ct Bldg code as of 1-1-06.

| **Unitary and Split Systems (A/C and Air source Heat Pumps)** | | |
|---|---|---|
| **Btu/h** | **Baseline** | **Minimum Compliance** |
| < 65,000 | 12 SEER | 13 SEER |
| ≥ 65,000 < 135,000 | 10.1 EER | 11 EER |
| ≥ 135,000 < 240,000 | 9.5 EER | 10.8 EER |
| ≥ 240,000 < 375,000 | 9.3 EER | 10 EER |
| ≥ 375,000 < 760,000 | 9.3 EER | 9.4 EER |
| ≥ 760,000 | 9 EER | 9.1 EER |