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Technical Reference User Manual (TRM)
No. 2009-1
Measure Savings Algorithms and Cost Assumptions

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1.0 Introduction

This reference manual provides methods, formulas and default assumptions for estimating energy and peak impacts from measures and projects promoted by Efficiency Maine's energy efficiency programs.

The reference manual is organized by program (or program component), end use and measure. Each section provides mathematical equations for determining savings (algorithms), as well as default assumptions for all equation parameters that are not based on site-specific information. In addition, any descriptions of calculation methods or baselines are provided, as appropriate. The parameters for calculating savings are listed in the same order for each measure. In order to maintain a similar appearance for all of the measure assumption pages, large tables are located at the end of the measure assumptions under the Reference Tables category. Algorithms are provided for estimating annual energy and demand impacts. Data assumptions are based on Maine specific data, where available. Where Maine data was not available, data from neighboring regions is used, including New York, New Jersey and New England, where available. In some cases, engineering judgment is used.

2.0 Gross-to-Net Savings Calculation

The algorithms shown with each measure calculate gross customer electric savings without counting the effects of line losses from the generator to the customer, freeridership, spillover, or persistence. The algorithms also do not distribute the savings among the different costing periods. The formulae for converting gross customer-level savings to net generation-level savings (counting freeridership, spillover and persistence) for the different costing periods are as follows:

$$\text{netkWh}_i = \Delta\text{kWh} \times (1+\text{LLF}_i) \times (1-\text{FR}+\text{SPL}) \times \text{PF} \times \text{AF}_i$$

$$\text{netkW}_j = \Delta\text{kW} \times (1+\text{LLF}_j) \times (1-\text{FR}+\text{SPL}) \times \text{PF} \times \text{CF}_j$$

Where:

netkWh_i = kWh energy savings at generation-level, net of free riders and persistence, and including spillover, for period i

i = subscript used to denote variable energy rating periods (Winter Peak, Winter Off-Peak, Summer Peak, Summer Off-Peak).

ΔkWh = gross customer annual kWh savings for the measure

LLF_i = line loss factor for period i

FR = freeridership

SPL = spillover for measure

PF = persistence factor for measure

AF_i = allocation of annual energy savings by season for period i

netkW_j = kW demand savings, net of free riders and persistence, and including spillover, for season j

j = subscript used to denote variable seasonal peaks (Summer and Winter)

ΔkW = gross customer connected load kW savings for the measure

LLF_j = line loss factor for seasonal peak j

CF_j = the percent of kW savings that is concurrent with Maine's seasonal peak, for season j

All of the parameters for the above equations may be found in the specific section for the measure, except for LLF, AF and CF. The line loss factors do not vary by measure, but by costing period, and are in the following table: AF and CF are presented in Table L1 below. The

line loss values are based upon CMP system line losses by voltage level. For residential customers we are using the loss factors for the secondary voltage level and for business customers the average value.¹

Line Loss Factors by Voltage Level

(These system losses exclude losses over PTF facilities)

Energy (LLFi)	Loss Factors by Voltage Level		
	Winter	Non-Winter	Average
Secondary	7.8%	8.3%	8.1%
Primary	4.0%	4.0%	4.1%
Sub-Transmission	1.4%	1.5%	1.5%
Transmission	0.2%	0.3%	0.3%
Average			6.5%
Peak (LLFj)			
Residential	7.8%	8.3%	
Business	6.5%	6.5%	

3.0 Interactive Effects

The TRM provides specific savings algorithms for many prescriptive measures. When a customer installs a prescriptive measure, the savings are determined according to these algorithms. In some cases these algorithms include the effects of interactions with other measures or end uses (e.g., cooling and heating effects from interior lighting waste heat). For “custom” measures, Efficiency Maine (EMaine) performs site-specific customized calculations. In this case, EMaine takes into account interactions between measures (e.g., individual savings from installation of window film and replacement of a chiller are not additive because the first measure reduces the cooling load met by the second measure). EMaine will calculate total savings for the package of custom measures being installed, considering interactive effects, either as a single package or in rank order of measures as described below. If a “custom” project includes both prescriptive and custom measures, the prescriptive measures will be calculated in the normal manner. However, the prescriptive measures will be assumed to be installed prior to determining the impacts for the custom measures. Custom interior lighting measures will use the standard prescriptive algorithm to estimating waste heat impacts.

In most cases of multiple custom measures EMaine models a single custom package including all measures the customer will install. This modeling effectively accounts for all interactions between measures, and the “package” is tracked in the EMaine data tracking and reporting system as a single “measure.” In instances where modeling is not completed on a package of measures, and where individual measures are separately listed in the data tracking and reporting system with measure-specific savings EMaine will use the following protocol (typically lighting only projects). To determine custom measure savings EMaine will calculate measure impacts in descending order of measure life (i.e., starting with the longest lived measure). The procedure is to calculate

¹ See the MPUC web site http://www.maine.gov/mpuc/electricity/rfps/standard_offer/sosmall0309/cmp_small_appg_bid100908.xls.

savings for the longest lived measure first, then consider that measure's impact on the next longest lived measure, and so on. This is because a short-lived measure can reduce savings from a long-lived measure, but only for part of its life. Since tracking system limitations require that annual measure savings remain constant for all years, this is the only way to ensure proper lifetime savings and total resource benefits are captured. For example, fixing compressed air leaks can reduce savings from installing a new compressor. However, leak repair only lasts 1 year. If the leak repair savings were calculated first the calculated lifetime savings and benefits from the compressor would be unreasonably low because compressor savings would go back up starting in year 2.

4.0 Persistence

Persistence factors may be used to reduce lifetime measure savings in recognition that initial engineering estimates of annual savings may not persist long term. This might be because a measure is removed or breaks prior to the end of its normal engineering lifetime, because it is not properly maintained over its lifetime, because it is overridden or goes out of calibration (controls only), or some other reason. Each measure algorithm contains an entry for persistence factor. The default value if none is indicated is 1.00 (100%). A value lower than 1.00 will result in a downward adjustment of lifetime savings and total resource benefits. For any measure with a persistence value less than 1.00, the normal measure life ("Engineering Measure Life") will be reduced to arrive at an "Adjusted Measure Life" for purposes of measure screening, savings and TRB claims, and tracking. The "Adjusted Measure Life" used will be equal to the product of the Engineering Measure Life and the persistence factor. Both the Engineering Measure Life and the Adjusted Measure Life will be shown in each measure algorithm.

5.0 Glossary

The following glossary provides definitions for necessary assumptions needed to calculate measure savings.

Baseline Efficiency (η_{base}): The assumed standard efficiency of equipment, absent an Efficiency Maine program.

Coincidence Factor (CF): Coincidence factors represent the fraction of connected load expected to be "on" and using electricity coincident with a particular electric system peak period, on a diversified basis. Coincidence factors are provided for summer and winter peak periods.

Connected Load: The maximum wattage of the equipment, under normal operating conditions, when the equipment is "on".

Freeridership (FR): This definition was obtained from the November 2006 evaluation report for the Efficiency Maine Business Program (page 1-6). A program's **free ridership rate** is the percentage of program participants deemed to be free riders. A **free rider** refers to a customer who received an incentive through an energy efficiency program who would have installed the same or a smaller quantity of the same high efficiency measure on their own within one year if the program had not been offered.

Full Load Hours (FLH): The equivalent hours that equipment would need to operate at its peak capacity in order to consume its estimated annual kWh consumption (annual kWh/connected kW).

High Efficiency (η_{effic}): The efficiency of the energy-saving equipment installed as a result of an energy efficiency program.

Lifetimes: The number of years (or hours) that the new high efficiency equipment is expected to function. These are generally based on engineering lives, but sometimes adjusted based on expectations about frequency of remodeling or demolition.

Line Loss Factor (LLF): The marginal electricity losses from the generator to the customer meter – expressed as a percent of meter-level savings. The Energy Line Loss Factors vary by period. The Peak Line Loss Factors reflect losses at the time of system peak, and are shown for two seasons of the year (winter and summer). Line loss factors are the same for all measures.

Load Factor (LF): The fraction of full load (wattage) for which the equipment is typically run.

Operating Hours (HOURS): The annual hours that equipment is expected to operate.

Persistence (PF): The fraction of gross measure savings obtained over the measure life.

Allocation of Annual Energy Savings by Season (AF): Allocation factors for defined times of the year that describe when energy savings will be realized for a specific measure. Allocation factors have been developed for four time periods: winter on and off-peak; and summer on and off-peak.

Spillover (SPL): This definition was obtained from the November 2006 evaluation report for the Efficiency Maine Business Program (page 1-7). **Spillover** refers to energy-efficient equipment installed by anyone due to program influences but without any financial or technical assistance from the Program. It is expressed as the percent increased in savings from a measure, relative to the savings for that measure attributable to program participants.

6.0 Loadshapes

The following table includes a listing of measure end-uses and associated loadshapes.

Table L1²

#	Enduse	Coincidence Factor		Allocation of Annual Energy Savings by Season			
		Winter	Summer	Winter		Summer	
				Peak	Off Peak	Peak	Off Peak
1	Residential Lighting	29%	8%	30%	40%	10%	20%

All loadshape numbers referenced in the measure characterizations correspond to the most recent generation of the loadshape as detailed in the loadshape table shown above. The coincidence factors in the standard load profile shown above are based on the listed assumptions for full load hours. To account for the effect on peak savings from a change in full load hours, use of full load hours different than the standard will result in an automatic adjustment of the coincident peak factors (% of connected load kW) used in screening and reported in the database, unless custom coincident peak factors are also entered. The coincidence factors are multiplied by the ratio of [custom full load hours]/[standard full load hours], with a maximum value of 100% for each factor. As a result, coincidence factors for particular measures may be higher or lower than the standard factors listed above even when a standard load profile is used.

² Efficiency Maine Benefit Cost Model, February 2009; the coincidence factor comes from Nexus Market Research, Inc. & RLW Analytics, Inc., Development of Common Demand Impacts Standards for Energy Efficiency Measures/Programs for the ISO Forward Capacity Market (FCM), March 25, 2007, pp. 10-11.

7.0 EMaine Current Time Period Definitions for Avoided Costs of Generation:

Winter Peak Energy: TBD

Winter Off-Peak Energy: TBD

Summer Peak Energy: TBD

Summer Off-Peak Energy: TBD

Summer Gen. Capacity: TBD

Winter Gen. Capacity: TBD

8.0 Measure Information

Compact Fluorescent Lamp

Measure Number: Residential-1 (R1)

Version Date & Revision History

Draft date: February 5, 2009
Effective date: February 5, 2009
End date: TBD

Referenced Documents

Compact Fluorescent Calculations 02-05-09.xls

Measure Description

An existing incandescent screw-in bulb is replaced with a lower wattage ENERGY STAR qualified compact fluorescent screw-in bulb. Fluorescent bulbs and fixtures present a significant opportunity for energy and maintenance savings. On a per lamp basis, compact fluorescent lamps are generally 70 percent more efficient than incandescent lamps and last up to ten times longer. Compact fluorescent light bulbs can be found in hardware stores as well as in chain stores such as Home Depot and Lowe's. CFL bulbs range in size and shape, and their appearance can be a spiral shaped fluorescent tube, or they can appear as a standard shape such as the R-30 floodlight for use in recessed cans.

Baseline Efficiencies – New or Replacement

The baseline condition is an incandescent light bulb.

High Efficiency

High efficiency is an ENERGY STAR qualified compact fluorescent lamp.

Operating Hours

Residential: 986 hours / year

Lifetimes

Lamp life is dependent on the average time interval that the lamp is left on. Most CFLs have a *rated* lifetime of 10,000 hours. However, units that are turned on and off more frequently have shorter lives and those that stay on for longer periods of time have longer lives. Thus, CFLs rebated through the Efficiency Maine Residential Lighting program are assumed to have a life of 7,500 hours or less for residential applications (assumed average daily usage of 2.7 hours). Based upon a measure life study for CFLs in New England, a measure life of 6.8 years is assumed.³

Algorithms

Demand Savings

$$\Delta kW = ((\text{Watts}_{\text{BASE}} - \text{Watts}_{\text{EE}}) / 1000) * \text{ISR}$$

Energy Savings

$$\Delta kWh = \Delta kW \times \text{HOURS}$$

³ Nexus Market Research, Inc. & RLW Analytics, Inc.. Residential Lighting Measure Life Study – Final, June 4, 2008, p. 1.

Where:

ΔkW = gross customer connected load kW savings for the measure

$Watts_{BASE}$ = Baseline connected kW

$Watts_{EE}$ = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used⁴

HOURS = average hours of use per year⁵

Savings Assumptions

Table R1-1⁶

Efficient CFL Wattage	Baseline Wattage	Annual Demand Savings (kW)	Customer Annual Savings (kwh)	ISR (In Service Rate)	Hours of Use	Useful Life (years)	Customer Lifetime Savings (kWh)
70	245	0.175	173	1	986	6.8	1173
69	242	0.173	171	1	986	6.8	1160
55	193	0.138	136	1	986	6.8	925
40	140	0.100	99	1	986	6.8	670
39	137	0.098	97	1	986	6.8	657
27	100	0.073	72	1	986	6.8	489
24	75	0.051	50	1	986	6.8	342
22	75	0.053	52	1	986	6.8	355
17	60	0.043	42	1	986	6.8	288
15	60	0.045	44	1	986	6.8	302
13	52	0.039	38	1	986	6.8	261
Unknown	N/A	0.050	49	1	986	6.8	332

⁴ ISR differs for residential and commercial applications. See table R1-1 for ISR in each application.

⁵ Hours of usage differs for residential applications. See table R1-1 for HOURS at each application.

⁶ Refer to Compact Fluorescent Calculations 10-26-06.xls for calculations.

Measure Full and Incremental Costs

Table R1-2

Efficient Measure Wattage	Full Cost of Efficient Measure	Full Cost of Baseline Measure	Incremental Cost
13 watts	\$4.97	\$0.25	\$4.72
15 watts	\$4.97	\$0.25	\$4.72
17 watts	\$4.97	\$0.25	\$4.72
22 watts	\$5.97	\$0.25	\$5.72
24 watts	\$5.97	\$0.25	\$5.72
27 watts	\$5.97	\$0.48	\$5.49
39 watts	\$9.97	\$2.49	\$7.48
40 watts	\$9.97	\$2.49	\$7.48
55 watts	\$12.99	\$2.49	\$10.50
69 watts	\$13.98	\$3.98	\$10.00
70 watts	\$13.98	\$3.98	\$10.00

Note: Cost data from Home Depot in Augusta, ME. Bulb costs reflect closest available in-store product. For example, the 13W, 15W and 17W CFL bulb costs are based on a 14W CFL bulb. Additionally, the 52W incandescent bulb is based on a standard 60W bulb.

O&M Cost Adjustments

Lifetime O&M Savings ⁷	
Residential	\$2.25

Loadshape

Loadshape #1: Residential Indoor Lighting⁸

Source: Vermont State Cost-Effectiveness Screening Tool.

Freeridership/Spillover Factors

Freeridership: 0.05⁹

Spillover: 0.25¹⁰

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

⁷ Based on avoiding the purchase of 9 incandescent bulbs, at a retail cost of \$.25 each.

⁸ See table L1 on page 7 for loadshape data.

⁹ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-14

¹⁰ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-15

Water Descriptions

N/A

Interior Fluorescent Fixture

Measure Number: Residential-2 (R2)

Version Date & Revision History

Draft date: October 30, 2006

Effective date: November 1, 2006

End date: TBD

Referenced Documents

Residential_Light_Fixture_Bulk.xls (EPA Savings Calculator – Residential Light Fixtures)

Measure Description

An existing lighting fixture with incandescent bulbs is replaced by an ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps in an interior setting.

Baseline Efficiencies – New or Replacement

The baseline condition is an interior incandescent light.

High Efficiency

High efficiency is an interior fluorescent fixture.

Operating Hours¹¹

Residential Applications: 766.5 hours / year

Lifetimes¹²

Residential: 20 years.

Analysis period is the same as the lifetime.

Algorithms

Demand Savings

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

Energy Savings

$$\Delta kWh = \Delta kW \times HOURS$$

Where:

ΔkW = gross customer connected load kW savings for the measure

$Watts_{BASE}$ = Baseline connected kW

$Watts_{EE}$ = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used¹³

HOURS = average hours of use per year¹⁴

¹¹ Massachusetts, Rhode Island and Vermont Impact Evaluation Report, [October 2004](#)

¹² Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

¹³ ISR differs for residential and commercial applications. See table R5-1 for ISR in each application.

¹⁴ Hours of usage differs for residential applications. See table R5-1 for HOURS at each application.

Savings Assumptions

Table R2-1 ¹⁵

Efficient Wattage	Baseline Wattage	Annual Demand Savings (kW)	Customer Annual Savings (kwh)	ISR (In Service Rate)	Hours of Use	Useful Life (years)	Customer Lifetime Savings (kWh)
36	120	0.084	64.4	1	766.5	20	1,288

Measure Full and Incremental Costs¹⁶

The incremental cost for this measure is \$40.

The total initial cost for this measure is \$60.

Table R2-2 ¹⁷

Efficient Measure (42W CFL)		Baseline Measure (120W Incandescent)	
Cost ¹⁸	Life ¹⁹	Cost ²⁰	Life ²¹
\$7.97	6.7 years	\$0.50	0.67 years

O&M Cost Adjustments

	Lifetime O&M Savings ²²
Residential	\$6.42

Loadshape

TBD

Freeridership/Spillover Factors

Freeridership: 0.08

Spillover: 0.04²³

¹⁵ Refer to Residential_Light_Fixture_Bulk.xls for calculations.

¹⁶ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

¹⁷ Costs and Lifetimes Used in Computing O&M Savings

¹⁸ Retail price for a 36 W CFL, based on data obtained from Home Depot in Augusta, Maine on October 10, 2006

¹⁹ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

²⁰ Retail price for a 120 W incandescent, based on data obtained from Home Depot in Augusta, Maine on October 20, 2006

²¹ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

²² Based on table R5-2

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A

Exterior Fluorescent Fixture

Measure Number: Residential-3 (R3)

Version Date & Revision History

Draft date: October 30, 2006

Effective date: November 1, 2006

End date: TBD

Referenced Documents

Residential_Light_Fixture_Bulk.xls (EPA Savings Calculator – Residential Light Fixtures)

Measure Description

An existing lighting fixture with incandescent bulbs is replaced by an ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps in an exterior setting.

Baseline Efficiencies – New or Replacement

The baseline condition is an exterior incandescent light fixture.

High Efficiency

High efficiency is an ENERGY STAR qualified exterior fluorescent fixture.

Operating Hours²⁴

Residential Applications: 1,460 hours/year

Lifetimes²⁵

Residential: 20 years.

Analysis period is the same as the lifetime.

Algorithms

Demand Savings

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

Energy Savings

$$\Delta kWh = \Delta kW \times HOURS$$

Where:

²³ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-15

²⁴ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures; Massachusetts, Rhode Island and Vermont Impact Evaluation Report

²⁵ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

ΔkW = gross customer connected load kW savings for the measure
 $Watts_{BASE}$ = Baseline connected kW
 $Watts_{EE}$ = Energy efficient connected kW
 ΔkWh = gross customer annual kWh savings for the measure
 ISR = in service rate or the percentage of units rebated that actually get used²⁶
 $HOURS$ = average hours of use per year²⁷

Savings Assumptions

Table R3-1²⁸

Efficient Wattage	Baseline Wattage	Annual Demand Savings (kW)	Customer Annual Savings (kWh)	ISR (In Service Rate)	Hours of Use	Useful Life (years)	Customer Lifetime Savings (kWh)
19	60	0.036	52	1	1,460	20	1,040

Measure Full and Incremental Costs²⁹

The incremental cost for this measure is \$40.
 The total initial cost for this measure is \$60.

Table R3-2³⁰

Efficient Measure (19W CFL)		Baseline Measure (60W Incandescent)	
Cost ³¹	Life ³²	Cost ³³	Life ³⁴
\$5.97	6.7 years	\$0.50	0.67 years

O&M Cost Adjustments

	Lifetime O&M Savings ³⁵
Residential	\$7.00

Loadshape

TBD

²⁶ ISR differs for residential and commercial applications. See table R6-1 for ISR in each application.

²⁷ Hours of usage differs for residential applications. See table R6-1 for HOURS at each application.

²⁸ Refer to Residential_Light_Fixture_Bulk.xls for calculations.

²⁹ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

³⁰ Costs and Lifetimes Used in Computing O&M Savings

³¹ Retail price for a 19 W CFL, based on data obtained from Home Depot in Augusta, Maine on October 10, 2006

³² Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

³³ Retail price for a 60 W incandescent, based on data obtained from Home Depot in Augusta, Maine on October 20, 2006

³⁴ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

³⁵ Based on table R6-2

Freeridership/Spillover Factors

Freeridership: 0.15³⁶

Spillover: 0.07³⁷

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A

Torchiere

Measure Number: Residential-4 (R4)

Version Date & Revision History

Draft date: October 30, 2006

Effective date: November 1, 2006

End date: TBD

Referenced Documents

Calc_Torchiere.xls (EPA Savings Calculator – Torchieres)

Measure Description

A high efficiency ENERGY STAR fluorescent torchiere replaces either a halogen or incandescent torchiere.

Baseline Efficiencies – New or Replacement

The baseline condition is halogen torchiere with sufficient usage to justify replacement.

High Efficiency

High efficiency is an ENERGY STAR torchiere designed for operation with pin-based CFLs.

Operating Hours³⁸

Residential: 2.5 hours/day => 912.5 hours / year

Lifetimes³⁹

10 years.

Analysis period is the same as the lifetime.

Algorithms

Demand Savings

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

³⁶ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-14

³⁷ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-15

³⁸ Engineering estimate of wattage savings and annual hours use of 912.5 hours from October 1, 2004 Massachusetts, Rhode Island and Vermont Impact Evaluation Report

³⁹ Residential Torchiere Assumptions, EPA Savings Calculator – Torchieres

Energy Savings

$$\Delta kWh = \Delta kW \times HOURS$$

Where:

ΔkW = gross customer connected load kW savings for the measure

$Watts_{BASE}$ = Baseline connected kW

$Watts_{EE}$ = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used⁴⁰

HOURS = average hours of use per year⁴¹

Savings Assumptions

Table R4-1⁴²

Efficient Wattage	Baseline Wattage	Annual Demand Savings (kW)	Customer Annual Savings (kWh)	ISR (In Service Rate)	Hours of Use	Useful Life (years)	Customer Lifetime Savings (kWh)
42	150	0.108	98.55	1	912.5	10	986

Measure Full and Incremental Costs⁴³

The incremental cost for this measure is \$40.

The total initial cost for this measure is \$60.

Table R4-2⁴⁴

Efficient Measure (42W Fluorescent)		Baseline Measure (150W Halogen)	
Cost ⁴⁵	Life ⁴⁶	Cost ⁴⁷	Life ⁴⁸
\$9.97	4.1 years	\$5.49	0.82 years

O&M Cost Adjustments

	Lifetime O&M Savings ⁴⁹
Residential	\$54.00

⁴⁰ ISR differs for residential and commercial applications. See table R7-1 for ISR in each application.

⁴¹ Hours of usage differs for residential applications. See table R7-1 for HOURS at each application.

⁴² Refer to Calc_Torchiere.xls for calculations.

⁴³ Residential Torchiere Assumptions, EPA Savings Calculator – Torchieres

⁴⁴ Costs and Lifetimes Used in Computing O&M Savings

⁴⁵ Retail price for a torchiere, based on data obtained from Home Depot in Augusta, Maine on October 10, 2006

⁴⁶ Residential Torchiere Assumptions, EPA Savings Calculator – Torchieres

⁴⁷ Retail price for a torchiere, based on data obtained from Home Depot in Augusta, Maine on October 20, 2006

⁴⁸ Residential Torchiere Assumptions, EPA Savings Calculator – Torchieres

⁴⁹ Residential Torchiere Assumptions, EPA Savings Calculator – Torchieres

Loadshape

TBD

Freeridership/Spillover Factors

Freeridership: 0.06⁵⁰

Spillover: 0.07⁵¹

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A

Ceiling Fan with ENERGY STAR Light Fixture

Measure Number: Residential-5 (R5)

Version Date & Revision History

Draft date: October 30, 2006

Effective date: November 1, 2006

End date: TBD

Referenced Documents

Caldwell and Horwitz (2001). "Ceiling Fans: Fulfilling the Energy Efficiency Promise". *Home Energy*. Jan/Feb.

Caldwell and Horowitz. Unpublished memo circulated through CEE.

Ceiling_Fan_Savings_Calculator_Consumer.xls (EPA Savings Calculator – Ceiling Fans)

Measure Description

This measure described energy savings associated with the use of integrated or attachable ENERGY STAR lighting fixture to an interior residential ceiling fan. If equipped with a light kit, then either fitted with an ENERGY STAR rated fixture or included with ENERGY STAR bulbs equal to the number of light sockets, as well as have separate fan and light switching. Energy savings are claimed only for the kWh savings attributable to lighting.

Baseline Efficiencies – New or Replacement

The baseline condition for fans with light kits assumes four sockets fitted with 60 watt incandescent bulbs. Based on information from manufacturer data and the Horowitz/Caldwell article in the Jan/Feb 2001 issue of Home Energy magazine.

High Efficiency

Energy Star fans with light kits assumes 2-D or circline Energy Star lamp totaling 60 watts. Conditions are based on information from manufacturer data and the Horowitz/Caldwell article in

⁵⁰ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-14

⁵¹ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-15

the Jan/Feb 2001 issue of Home Energy magazine. Efficiency of fans at low speed must be at least 155 CFM/Watt and at high speed must be 75 CFM/Watt.⁵²

Operating Hours⁵³

Residential Applications: 1,460 hours/year

Lifetimes⁵⁴

Lifetime for this measure is 10 years.
Analysis period is the same as the lifetime.

Algorithms

Demand Savings

$$\Delta kW = ((\text{Watts}_{\text{BASE}} - \text{Watts}_{\text{EE}}) / 1000) * \text{ISR}$$

Energy Savings

$$\Delta kWh = \Delta kW \times \text{HOURS}$$

Where:

ΔkW = gross customer connected load kW savings for the measure

$\text{Watts}_{\text{BASE}}$ = Baseline connected kW

Watts_{EE} = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used⁵⁵

HOURS = average hours of use per year⁵⁶

Savings Assumptions

Table R5-1⁵⁷

Efficient Wattage	Baseline Wattage	Annual Demand Savings (kW)	Customer Annual Savings (kwh)	ISR (In Service Rate)	Hours of Use	Useful Life (years)	Customer Lifetime Savings (kWh)
60	180	0.120	175.2	N/A	1,460	10	1,752

Measure Full and Incremental Costs

The incremental cost for this measure is \$25.⁵⁸

A basic light kit and ceiling fan costs between \$8.97 and \$36.⁵⁹

Total initial cost for the high efficiency measure would be \$61.

⁵² ENERGY STAR website: http://www.energystar.gov/index.cfm?c=ceiling_fans.pr_crit_ceiling_fans

⁵³ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures; Massachusetts, Rhode Island and Vermont Impact Evaluation Report; Based on 4 hours/day, 365 days/yr

⁵⁴ Assumptions for Ceiling Fans with Lighting, EPA Savings Calculator – Ceiling Fans, 2005

⁵⁵ ISR differs for residential and commercial applications. See table R8-1 for ISR in each application.

⁵⁶ Hours of usage differs for residential applications. See table R8-1 for HOURS at each application.

⁵⁷ Refer to Ceiling_Fan_Savings_Calculator_Consumer.xls for calculations.

⁵⁸ Assumptions for Ceiling Fans with Lighting, EPA Savings Calculator – Ceiling Fans, 2005

⁵⁹ Retail price for a 4-lamp ceiling fan with light kit, based on data obtained from Home Depot in Augusta, Maine on October 20, 2006

Table R5-2⁶⁰

Component	Efficient Measure		Baseline Measure	
	Cost ⁶¹	Life ⁶²	Cost ⁶³	Life ⁶⁴
3 Light Bulbs	\$17.91	6.7 years	\$1.50	0.67 years
Ballast	\$20.00	25.05 years	N/A	N/A

O&M Cost Adjustments

	Lifetime O&M Savings ⁶⁵
Residential	\$13.50

Loadshape

TBD

Freeridership/Spillover Factors

Freeridership: 0.02⁶⁶

Spillover: 0.07⁶⁷

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A

⁶⁰ Costs and Lifetimes Used in Computing O&M Savings

⁶¹ Retail price for a three 20W CFLs, based on data obtained from Home Depot in Augusta, Maine on October 10, 2006

⁶² Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

⁶³ Retail price for three 60 W incandescent bulbs, based on data obtained from Home Depot in Augusta, Maine on October 20, 2006

⁶⁴ Assumptions for Residential Lighting Fixtures, EPA Savings Calculator – Lighting Fixtures

⁶⁵ Assumptions for Ceiling Fans with Lighting, EPA Savings Calculator – Ceiling Fans, 2005

⁶⁶ EVT Technical Reference User Manual (TRM) No. 2006-41.

⁶⁷ ibid

LED Holiday Lights

Measure Number: Residential-6 (R6)

Version Date & Revision History

Draft date: December 27, 2006
Effective date: December 27, 2006
End date: TBD

Referenced Documents

LED Christmas Lights 5-19-06.xls

Measure Description

LED Holiday lights use light emitting diodes rather than the traditional miniature incandescent bulbs. LEDs are much like incandescent bulbs except that they do not have a filament inside that can burn out and take the entire string of bulbs with it. Instead, they are illuminated by the movement of electrons in a semi-conductor material.

Baseline Efficiencies – New or Replacement

The baseline condition is a string of the traditional miniature incandescent holiday bulbs.

High Efficiency

High efficiency is a string of LED Holiday lights.

Operating Hours⁶⁸

Residential: 150 hours/year (5 hours a day, 30 days a year)

Lifetimes⁶⁹

20 years

*Analysis period is the same as the lifetime.

Algorithms

Demand Savings

$$\Delta kW = ((\text{Watts}_{\text{BASE}} - \text{Watts}_{\text{EE}}) / 1000) * \text{ISR}$$

Energy Savings

$$\Delta kWh = \Delta kW \times \text{HOURS}$$

Where:

ΔkW = gross customer connected load kW savings for the measure

$\text{Watts}_{\text{BASE}}$ = Baseline connected kW

Watts_{EE} = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used

HOURS = average hours of use per year

⁶⁸ Washington State University Cooperative Extension Energy Program and Northwest Energy Efficiency Alliance. Energy Efficiency Fact Sheet, Holiday Lights

⁶⁹ ibid

Savings Assumptions

Table R6-1A

Efficient Measure Wattage	Baseline Wattage	Annual Demand Savings	Customer Annual Savings (kwh)	ISR (In Service Rate)	Hours of Use	Useful Life (years)	Customer Lifetime Savings (kWh)
50 (C7 LED Lamps) ⁷⁰	100 (25 C7s) ⁷¹	0.45	67.5	1	150	20	1350
11.2 (Mini LED Lamps) ⁷²	45 (100 Mini Lights) ⁷³	.1148	17.22	1	150	20	344.4

*Note: C7 lights used are 5X25 lamp strings to cover an 8 foot tree. Mini lights used are 4X70 lamp strings to cover the same 8 foot tree.

Measure Full and Incremental Costs

Table R6-2

Efficient Measure Wattage	Full Cost of Efficient Measure	Full Cost of Baseline Measure	Incremental Cost
50 (C7 LED Lamps)	TBD	TBD	TBD
11.2 (Mini LED Lamps)	TBD	TBD	TBD

Loadshape

TBD

Freeridership/Spillover Factors

Freeridership: TBD

Spillover: TBD

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A

⁷⁰ Proposal for Decorative Light Strings for Inclusion as Part of the Energy Star Program. Prepared for US EPA. March 2006, by Office of Energy Efficiency Natural Resources Canada and Navigant Consulting, Inc.

⁷¹ ibid

⁷² ibid

⁷³ PG&E. http://www.pge.com/res/holiday_lighting.html

O&M Cost Adjustments

	Lifetime O&M Savings
Residential	

Freeridership/Spillover Factors
Freeridership: 0.05⁷⁴

Low Income Lighting

Measure Number: Low Income-1 (L11)

Version Date & Revision History

Draft date: February 5, 2009
Effective date: February 5, 2009
End date: TBD

Referenced Documents

Nexus Market Research, Inc. & RLW Analytics, Inc., Process and Impact Evaluation of the Low Income Appliance Replacement Program – Final, December 21, 2007

Measure Description

Potential participants are usually identified by CAP agencies through the face-to-face Low Income Home Energy Assistance Program (LIHEAP) application process. If the client meets all the eligibility criteria, the program schedules an appointment for an auditor to visit the home. Each audit lasts about two and one half hours, which includes metering the refrigerator, providing CFLs, conducting a blower door test, and educating the client. The auditor meters the refrigerator for two hours in order to estimate annual kWh usage. While metering the refrigerator, the auditor provides CFLs, educates the client regarding appliance usage and lifestyle habits that may affect energy usage, and distributes LIARP information regarding refrigerator maintenance and CFL recycling.

Baseline Efficiencies – New or Replacement

The baseline condition is an incandescent light bulb.

High Efficiency

High efficiency is an ENERGY STAR qualified compact fluorescent lamp.

Operating Hours

Residential: 986 hours / year

Lifetimes

Lamp life is dependent on the average time interval that the lamp is left on. Most CFLs have a *rated* lifetime of 10,000 hours. However, units which are turned on and off more frequently have shorter lives and those that stay on for longer periods of time have longer lives. Thus, CFLs rebated through this program are assumed to have a life of 7,500 hours with an assumed

⁷⁴ Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Table 4-14

average daily usage of 3.96 hours for residential low income households. At this rate, the useful life of a CFL bulb (7,500 hrs) is 5.18 years.

Algorithms

Demand Savings

$$\Delta kW = ((\text{Watts}_{\text{BASE}} - \text{Watts}_{\text{EE}}) / 1000) * \text{ISR}$$

Energy Savings

$$\Delta kWh = \Delta kW \times \text{HOURS}$$

Where:

ΔkW = gross customer connected load kW savings for the measure

$\text{Watts}_{\text{BASE}}$ = Baseline connected kW

Watts_{EE} = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used

HOURS = average hours of use per year

Savings Assumptions

Based upon the 2007 program evaluation performed by Nexus Market Research, Inc. & RLW Analytics, Inc. (Process and Impact Evaluation of the Low Income Appliance Replacement Program – Final, December 21, 2007) average annual kWh savings per CFL replacement is assumed to be 35.7 kWh.

Measure Full and Incremental Costs

The cost for this measure, based on FY08 costs, is \$2.25 per CFL.

Loadshape

Same as residential CFL program.

Freeridership/Spillover Factors

Freeridership: TBD

Spillover: TBD

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A

Low Income Refrigerators

Measure Number: Low Income-2 (LI2)

Version Date & Revision History

Draft date: February 5, 2009

Effective date: February 5, 2009

End date: TBD

Referenced Documents

Nexus Market Research, Inc. & RLW Analytics, Inc., Process and Impact Evaluation of the Low Income Appliance Replacement Program – Final, December 21, 2007

Measure Description

Potential participants are usually identified by CAP agencies through the face-to-face Low Income Home Energy Assistance Program (LIHEAP) application process. If the client meets all the eligibility criteria, the program schedules an appointment for an auditor to visit the home. Each audit lasts about two and one half hours, which includes metering the refrigerator, providing CFLs, conducting a blower door test, and educating the client. The auditor meters the refrigerator for two hours in order to estimate annual kWh usage. While metering the refrigerator, the auditor provides CFLs, educates the client regarding appliance usage and lifestyle habits that may affect energy usage, and distributes LIARP information regarding refrigerator maintenance and CFL recycling.

Baseline Efficiencies – New or Replacement

The baseline condition is an existing refrigerator, manufactured at least 10 years prior to the current date, which the participant owns and pays the electric bill for.

High Efficiency

High efficiency is an ENERGY STAR qualified refrigerator.

Operating Hours

Residential: 5,000 hours / year

Lifetimes

The measure life is assumed to be 7 years.

Algorithms

Demand Savings

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

Energy Savings

$$\Delta kWh = \Delta kW \times HOURS$$

Where:

ΔkW = gross customer connected load kW savings for the measure

$Watts_{BASE}$ = Baseline connected kW

$Watts_{EE}$ = Energy efficient connected kW

ΔkWh = gross customer annual kWh savings for the measure

ISR = in service rate or the percentage of units rebated that actually get used

HOURS = average hours of use per year

Savings Assumptions

Based upon the 2007 program evaluation performed by Nexus Market Research, Inc. & RLW Analytics, Inc. (Process and Impact Evaluation of the Low Income Appliance Replacement Program – Final, December 21, 2007) average annual kWh savings per refrigerator replacement is assumed to be 1,361 kWh.

Measure Full and Incremental Costs

The cost for this measure, based on FY08 costs, is \$552

Loadshape

Loadshape #4, Residential Refrigeration, Vermont State Cost-Effectiveness Screening Tool.

Freeridership/Spillover Factors

Freeridership: TBD

Spillover: TBD

Persistence

The persistence factor is assumed to be 1.0.

Fossil Fuel Descriptions

N/A

Water Descriptions

N/A