Big Rivers
ELECTRIC CORPORATION

Your Touchstone Energy® Cooperative

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION OF KENTUCKY

In the Matter of:

2014 INTEGRATED RESOURCE PLAN OF BIG RIVERS ELECTRIC CORPORATION	))	Case No. 2014-00166

Attachments for Response to Item 5 of
Ben Taylor and the Sierra Club's Initial Request for Information
dated August 20, 2014
(*Provided on electronic media*)

Indiana Technical Resource Manual
Version 1.0
January 10, 2013

FILED: September 10, 2014

BIG RIVERS ELECTRIC CORPORATION

2014 INTEGRATED RESOURCE PLAN
OF BIG RIVERS ELECTRIC CORPORATION
CASE NO. 2014-00166

Response to Ben Taylor and Sierra Club's
Initial Request for Information
Dated August 20, 2014

September 10, 2014

Item 5) **Refer to page 17, footnote 15 of the IRP. Produce the Indiana Technical Resource Manual referenced therein**

Response) Please refer to the attachment provided by electronic media.

Witness) Russ Pogue

Indiana Technical Resource Manual

Version 1.0
January 10, 2013

Prepared for the
Indiana Demand Side Management Coordination Committee EM&V Subcommittee

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I. Introduction

This Technical Reference Manual (TRM) was developed at the request of the Indiana (DSMCC). It is based on the Draft Ohio TRM developed by the Vermont Energy Investment Corporation (VEIC) under contract to the Public Utility Commission of Ohio (PUCO). The DSMCC directed the Indiana utilities to use the Draft Ohio TRM to develop program plans and ex-ante savings estimates. This project seeks to update the Ohio TRM with Indiana-specific data for climate-sensitive measures and parameters, add additional measures as needed to support the DSMCC, and update all measure sections with more current information.

The savings estimates are expected to serve as representative, recommended values, or ways to calculate savings based on program-specific information. All information is presented on a per measure basis. In using the measure-specific information in the TRM, it is helpful to keep the following notes in mind.

- The TRM clearly identifies whether the measure impacts pertain to “retrofit”, “time of sale”,[1] or “early retirement” program designs.

- Additional information about the program design is sometimes included in the measure description, because program design can affect savings and other parameters.

- Savings algorithms are provided for each measure. For a number of measures, prescriptive values for each of the variables in the algorithm are provided along with the output from the algorithm. That output is the deemed savings assumption. For other measures, prescriptive values are provided for only some of the variables in the algorithm, with the term “actual” or “actual installed” provided for the others. In those cases – which one might call “deemed calculations”– users of the TRM are expected to use actual efficiency program data (e.g., capacities or rated efficiencies of central air conditioners) in the formula to compute savings. Note that the TRM often provides example calculations for measures requiring “actual” values. These are for illustrative purposes only.

- All estimates of savings are for annual savings, however, parameters for calculating life cycle savings (such as measure life) are also included.

- Unless otherwise noted, measure life is defined to be the life of an energy consuming measure, including its equipment life and measure persistence.

- Where deemed values for savings are provided, these represent average savings that could be expected from the average measures that might be installed in the region in 2012.

- For measures that are not weather-sensitive, peak savings are estimated whenever possible as the average of savings between 3 pm and 6 pm across all summer weekdays (the Indiana summer on-peak period).

[1] In some jurisdictions, this is called “replace on burn-out”. We use the term “time of sale” because not all new equipment purchases take place when an older existing piece of equipment reaches the end of its life.

- Wherever possible, savings estimates and other assumptions are based on Indiana or regional data. However, a number of assumptions are based on sources from other regions of the country. While this information is not perfectly transferable, due to differences in definitions of peak periods as well as geography and climate and customer mix, it was used because it was the most transferable and usable source available at the time.

- Users will note that the TRM presents a combination of engineering equations and building energy simulation results. Engineering equations were judged to be desirable because they convey information clearly and transparently, and they are widely accepted in the industry. The equations provide flexibility and opportunity for users to substitute locally specific information and to update some or all parameters as they become available on an ad hoc basis. One limitation is that certain interaction effects between end uses, such as how reductions in waste heat from many efficiency measures impacts space conditioning, are not universally captured in this version of the TRM. Such interactive factors are included in calculations for lighting measures. For measures where simple engineering equations do not adequately predict energy savings, simulation model results are presented. Engineering equations may also use parameters derived from simulation modeling. A description of the prototypical building models used in the simulations is shown in Appendix F.

- Many C&I measures are based on building energy simulations. This was typically done for complex, highly interactive measures, such as envelope improvements or chilled water resets. The building prototype assumptions are primarily based on California's Database of Energy-Efficient Resources (DEER) prototypes with adjustments based on data published by the U.S. Energy Information Administration's (EIA) Commercial Building Energy Consumption Survey (CBECS).

- For early replacement measures across all sectors, we have provided two levels of savings:

    - An initial period during which the existing inefficient unit would have continued to be used had it not been replaced (and savings claimed between the existing unit and the efficient replacement).

    - The remainder of the measure life, where we assume that the existing unit would have been replaced with a standard baseline unit (and so savings are claimed between the standard baseline and the efficient replacement).

      We assume that accounting for this step-down adjustment in annual savings is possible in the utilities' tracking systems. We have also provided the impact of the deferred replacement payment that would have occurred at the end of the useful life of the existing equipment.

- In general, the baselines included in the TRM are intended to represent average conditions in Indiana. Some are based on data from the state, such as household consumption characteristics provided by the Energy Information Administration. Some are extrapolated from other areas, when Indiana data are not available. When weather adjustments were needed in extrapolations, weather conditions in all major Indiana cities were generally used as representative for their regions.

- The TRM anticipates the effects of changes in efficiency standards for some measures, specifically CFLs and T-12 linear fluorescent lamps. Specific reductions in savings have been incorporated for CFL measures that relate to the shift in appropriate baseline due to changes in Federal Standards for lighting products. In 2012, Federal legislation (stemming from the Energy Independence and Security Act of 2007) will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase-out of the current style, or "standard", incandescent bulbs. In 2012, standard 100W incandescent bulbs will no longer be manufactured, followed by restrictions on standard 75W bulbs in 2013 and 60W bulbs in 2014. The baseline for the CFL measure in those years will therefore become bulbs (improved, or "efficient", incandescent, or halogen) that meet the new standard but are still less efficient than a CFL. The industry has indicated that new products that meet the federal standards but are less efficient than CFLs will be on the market. Those products can take several different forms we can envision now and perhaps others we do not yet know about; halogens are one of those possibilities and have been chosen to represent a baseline at that time. CFL fixtures will also have savings reduced by approximately 50% after the first year. Other lighting measures will also have baseline shifts that could result in significant impacts to estimated savings. As of July 14, 2012, Federal standards will require that all newly manufactured or imported T-12 linear fluorescents meet strict new efficacy requirements. T-12 lamps will be available from inventory, and manufacturers are starting to promote high color rendering (CRI) T-12 lamps that are exempt from the regulations. Standard T-8 lamps may be come the baseline for linear fluorescent lighting systems as the market adapts to the new regulations.

TRM Updating Process

Updates to the Indiana TRM will be initiated when Indiana impact evaluations have established sufficient evidence to suggest that a change to a specific TRM calculation is needed or when there is enough evidence within the energy efficiency program evaluation field to suggest that a change to the Indiana TRM is needed. As such, it is not recommended that a change be initiated unless the Evaluation Administrator and the Subcommittee have collectively decided that a change is necessary and the evidence is reliably consistent (i.e. initiate an up-date only when a savings pattern or technology use condition is consistent).

Following the instructions of the Subcommittee, at the end of each program cycle (when reliability of the evaluation results are highest) the evaluation administrator should launch a comparative assessment of the TRM estimated gross ex ante impacts associated the installed measures and the ex post evaluated energy impact results for those measures (when applicable) and assess if the savings levels are statistically different. If the measure-specific savings are found to be statically different, and the cause of that difference can be identified as being associated with typical installation and use conditions or a change in typical baseline conditions, or a change in the efficiency level of the covered TRM equation, the evaluation contactor should develop a new ex ante TRM estimation approach and provide a change recommendation to Subcommittee. A majority vote by the Subcommittee is required to accept the recommendation and to update the TRM.

Each change to the TRM will be documented in a revised TRM in a way similar to the change documentation approach for updating the Indiana Evaluation Framework. That is, each change will be recorded in a *TRM Changes and Updates Appendix* located at the end of the TRM. The changes will be recorded in a "change table" in a way consistent with the instructions contained in the Indiana Evaluation Framework to include the following information.

Table 1. TRM Changes and Updates Table

Change #	Date of Subcommittee acceptance	Section of TRM Changed	Summary of the change and reason for the change
1	xx/xx/20xx		
2			
3			
4			
5			
6			
7			
8			
9			
10			

Adding New Measures to the TRM

The Third Party Program Administrator or the Independent Evaluation Administrator can recommend to the EM&V Subcommittee the addition of new measures to the TRM. Likewise the Subcommittee can instruct the Evaluation Administrator to include a new measure to the TRM if in the opinion of a majority vote of the Subcommittee a measure should be added. New measures can be added to the TRM at any time, subject to approval by the Subcommittee.

The following sections of the TRM present the ex ante calculation approach for estimating the projected energy impacts from program implementation efforts undertaken following the release date of this document.

II. Residential Market Sector

Residential ENERGY STAR Compact Fluorescent Lamp (CFL) (Time of Sale)

Official Measure Code: Res-Ltg-CFL-TOS-1

Description

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is purchased through a retail outlet in place of an incandescent screw-in bulb. The incremental cost of the CFL compared to the incandescent light bulb is offset via either rebate coupons or via upstream markdowns. Assumptions are based on a time of sale purchase, not as a retrofit or direct install installation.

This characterization assumes that the CFL is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known and absent verifiable evaluation data to support an appropriate residential vs. commercial split, it is recommended to use this residential characterization for all purchases to be appropriately conservative in savings assumptions.

Definition of Efficient Equipment

In order for this characterization to apply, the high-efficiency equipment must be a standard ENERGY STAR qualified compact fluorescent lamp.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be an incandescent light bulb.

Deemed Calculation for this Measure

Annual kWh Savings $= (CFL_{Watts} * 3.25) * 0.891$

Summer Coincident Peak kW Savings $= (CFL_{Watts} * 3.25) * 0.000106$

Annual MMBtu $= (CFL_{Watts} * 3.25) * - 0.0017$

Note: the delta watts multiplier of 3.25 will be adjusted in accordance with table presented below:

CFL Wattage	Delta Watts Multiplier[2]		
	2012	2013	2014 and Beyond
15 or less	3.25	3.25	2.05
16-20	3.25	2.00	2.00
21W+	2.06	2.06	2.06

Adjustment to annual savings within life of measure:

CFL Wattage	Savings as Percentage of Base Year		
	2012	2013	2014 and Beyond
15 or less	100%	100%	63%
16-20	100%	62%	62%
21W+	63%	63%	63%

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years[3].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $3[4].

Deemed O&M Cost Adjustments

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.52	$4.52
16-20W	$4.52	$4.52
15W and less	$4.74	$4.74

Coincidence Factor

The summer peak coincidence factor for this measure is 0.11[5].

[2] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).
[3] Calculated using average rated life of compact fluorescent bulbs of 10,000 hours, including DEER switching adjustment factor of 0.523 (10000/1040*0.523 = 5 years).
[4] Based on review of TRM assumptions from Vermont, New York, New Jersey and Connecticut.
[5] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = ((ΔWatts) /1000) * ISR * HOURS * (1+WHF_e)

Where:

ΔWatts = Compact Fluorescent Watts * 3.25[6]

Note: The multiplier should be adjusted according to the table below to account for the change in baseline stemming from the Energy Independence and Security Act of 2007 discussed below:

CFL Wattage	Delta Watts Multiplier[7]		
	2012	2013	2014 and Beyond
15 or less	3.25	3.25	2.05
16-20	3.25	2.00	2.00
21W+	2.06	2.06	2.06

ISR = In Service Rate or percentage of units rebated that get installed.
= 0.91[8]

HOURS = Average hours of use per year
= 1040 (2.85 hrs per day)[9]

WHF_e = Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.

For example, a 20watt CFL bulb installed in 2012 using Statewide average for HVAC interactive effects:

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[6] Average wattage of compact fluorescent from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program" study was 15.47W, and the replacement incandescent bulb was 65.8W (note only data from responses who reported both wattage removed and wattage replaced are used). This is a ratio of 4.25 to 1, and so the delta watts is equal to the compact fluorescent bulb multiplied by 3.25.

[7] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014). For example, average CFL size replacing a 60W incandescent is 60/(4.25) = 14.1 W. When the 60W incandescent is replaced by a 43W halogen, the delta watts becomes 43 – 14.1 = 28.9, and the delta watts multiplier becomes 28.9/14.1 = 2.05.

[8] Starting with a first year ISR of 0.86 (Duke Energy Residential Smart $aver CFL Programs in North Carolina and South Carolina, February 2011) and assuming 3% of the lamps never get installed, and 43% of the remaining 11% not installed in the first year replace incandescents (24 out of 56 respondents not purchased as spares; Nexus Market Research, RLW Analytics, October 2004; "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs", table 6-4). ISR is therefore calculated as 0.86 + (0.43*0.11) = 0.91.

[9] Based on weighted average daylength adjusted hours from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program"

$$\Delta kWh = ((20 * 3.25)/1000) * 0.91 * 1040 * (1 - 0.059)$$

$$= 57.9 \text{ kWh}$$

Baseline Adjustment

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[10]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[11]:

CFL Wattage	Savings as Percentage of Base Year Savings		
	2012	2013	2014 and Beyond
15 or less	100%	100%	63%
16-20	100%	62%	62%
21W+	63%	63%	63%

Summer Coincident Peak Demand Savings

$$\Delta kW = ((\Delta Watts)/1000) * ISR * (1+WHF_d) * CF$$

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.11

[10] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

[11] Calculated by finding the percentage reduction in change of delta watts, for example change in 100W bulb: (72-23.5)/(100-23.5) = 63.4%

For example, a 20watt CFL bulb installed in 2012 using Statewide average for HVAC interactive effects:

$$\Delta kW = ((20*3.25) / 1000) * 0.91 * (1 + 0.057) * 0.11$$

$$= 0.0069 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBTU_{WH} = (((\Delta Watts) /1000) * ISR * HOURS * WHF_g$$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

For example, a 20watt CFL bulb installed in 2012 using Statewide average HVAC interactive effects:

$$\Delta MMBTU_{WH} = ((20 * 3.25)/1000) * 0.91 * 1040 * -0.0018$$

$$= - 0.11 \text{ MMBtu}$$

Deemed O&M Cost Adjustment Calculation

In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated.

The key assumptions used in this calculation are documented below:

	Standard Incandescent	Halogen
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	1[12]	3[13]

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

[12] Assumes rated life of incandescent bulb of approximately 1000 hours.
[13] Best estimate of future technology from Ohio TRM.

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.52	$4.52
16-20W	$4.52	$4.52
15W and less	$4.74	$4.52

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Referenced Documents:
On the following page is an Excel worksheet showing the calculation for the levelized annual replacement cost savings.

Calculation of O&M Impact for Baseline

Measure Life: 9
Real Discount Rate: 5%

	Bulb Assumptions	
	Inc	Halogen
Component 1 Life (years)	1	3
Component 1 Replacement Cost	$0.50	$2.00

2012

		Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
		NPV									
21W+	Baseline Replacement Costs	$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00
16-20W	Baseline Replacement Costs	$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00
15W and less	Baseline Replacement Costs	$5.21	$0.00	$0.50	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.97	$4.97
16-20W	$4.97	$4.97
15W and less	$5.21	$4.97

Multiply by 0.91 ISR

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.52	$4.52
16-20W	$4.52	$4.52
15W and less	$4.74	$4.52

Residential Direct Install - ENERGY STAR Compact Fluorescent Lamp(CFL) (Early Replacement)

Official Measure Code: Res-Ltg-CFL-DI-1

Description

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb is installed by an auditor, contractor or member of utility staff, in a residential location in place of an existing incandescent screw-in bulb through a Direct Install program. The characterization assumes protocols are implemented that guide installation of the bulb in to high use locations in the home. The CFL is provided at no cost to the end user.

Definition of Efficient Equipment

In order for this characterization to apply, the high-efficiency equipment must be an ENERGY STAR qualified compact fluorescent lamp.

Definition of Baseline Equipment

In order for this characterization to apply, the existing baseline equipment is assumed to be an incandescent light bulb.

Deemed Calculation for this Measure

Annual kWh Savings $= (CFL_{Watts} * 3.25) * 0.87$

Summer Coincident Peak kW Savings $= (CFL_{Watts} * 3.25) * 0.000103$

Annual MMBtu Increase $= (CFL_{Watts} * 3.25) * 0.0017$

Note: the delta watts multiplier of 3.25 will be adjusted in accordance with table presented below:

CFL Wattage	Delta Watts Multiplier[14]		
	2012	2013	2014 and Beyond
15 or less	3.25	3.25	2.05
16-20	3.25	2.00	2.00
21W+	2.06	2.06	2.06

[14] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

Adjustment to annual savings within life of measure:

CFL Wattage	Savings as Percentage of Base Year		
	2012	2013	2014 and Beyond
15 or less	100%	100%	63%
16-20	100%	62%	62%
21W+	63%	63%	63%

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years[15].

Deemed Measure Cost

The full cost for this measure should be equal to the actual cost for implementation and installation (i.e. the cost of product and the labor for its installation).

Deemed O&M Cost Adjustments

The calculated levelized annual replacement cost savings for CFL type and installation year are presented below:

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.03	$4.03
16-20W	$4.03	$4.03
15W and less	$3.12	$4.03

Coincidence Factor

The summer peak coincidence factor for this measure is 0.11[16].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = ((\Delta Watts) / 1000) * ISR * HOURS * (1+WHF_e)$$

[15] Calculated using average rated life of compact fluorescent bulbs of 10,000 hours, including DEER switching adjustment factor of 0.523 (10000/1040*0.523 = 5 years). Note, a provision in the Energy Independence and Security Act of 2007 requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the CFL baseline. Therefore after 2014 the measure life will have to be reduced each year to account for the number of years remaining to 2020.

[16] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

Where:

ΔWatts = Compact Fluorescent Watts * 3.25[17]

Note: The multiplier should be adjusted according to the table below to account for the change in baseline stemming from the Energy Independence and Security Act of 2007 discussed below:

CFL Wattage	Delta Watts Multiplier[18]		
	2012	2013	2014 and Beyond
15 or less	3.25	3.25	2.05
16-20	3.25	2.00	2.00
21W+	2.06	2.06	2.06

ISR = In Service Rate or percentage of units rebated that get installed.
= 0.89 [19]
HOURS = Average hours of use per year
= 1040 (2.85 hrs per day)[20]
WHF_e = Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.

For example, a 20watt CFL bulb installed in 2012 using Statewide average HVAC interactive effects:

ΔkWh = ((20 * 3.25) / 1000) * 0.89 * 1040 * (1 - 0.059)

= 56.6 kWh

Baseline Adjustment
Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard

[17] Average wattage of compact fluorescent from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program" study was 15.47W, and the replacement incandescent bulb was 65.8W (note only data from responses who reported both wattage removed and wattage replaced are used). This is a ratio of 4.25 to 1, and so the delta watts is equal to the compact fluorescent bulb multiplied by 3.25.
[18] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014). For example, average CFL size replacing a 60W incandescent is 60/(4.25) = 14.1 W. When the 60W incandescent is replaced by a 43W halogen, the delta watts becomes 43 – 14.1 = 28.9, and the delta watts multiplier becomes 28.9/14.1 = 2.05.
[19] Duke Energy data on ISR for direct install programs. Note, the ISR does not account for stored lamps that may be installed later. Assumes uninstalled DI lamps have been permanently removed.
[20] Based on weighted average daylength adjusted hours from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program"

incandescent bulbs[21]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[22]:

CFL Wattage	Savings as Percentage of Base Year Savings		
	2012	2013	2014 and Beyond
15 or less	100%	100%	63%
16-20	100%	62%	62%
21W+	63%	63%	63%

Summer Coincident Peak Demand Savings

$$\Delta kW = ((\Delta Watts) /1000) * ISR * WHF_d * CF$$

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.11

For example, a 20watt CFL bulb, installed in 2012 using Statewide average HVAC interactive effects:

$$\Delta kW = ((20 * 3.25) / 1000) * 0.89 * (1 + 0.057) * 0.11$$

$$= 0.0067 \text{ kW}$$

[21] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf
[22] Calculated by finding the percentage reduction in change of delta watts, for example change in 100W bulb: (72-23.5)/(100-23.5) = 63.4%

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBTU_{WH} = ((\Delta Watts) / 1000) * ISR * HOURS * WHF_g$$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

For example, a 20watt CFL bulb, installed in 2012 using statewide average for HVAC interactive effects:

$$\Delta MMBTU_{WH} = ((20 * 3.25)/1000) * 0.89 * 1040 * -0.0018$$

$$= -0.11 \text{ MMBtu}$$

Deemed O&M Cost Adjustment Calculation

In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated.

The key assumptions used in this calculation are documented below:

	Standard Incandescent	Halogen
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	1[23]	3[24]

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.42	$4.42
16-20W	$4.42	$4.42
15W and less	$3.44	$4.42

[23] Assumes rated life of incandescent bulb of approximately 1000 hours.
[24] Best estimate of future technology from Ohio TRM.

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Referenced Documents:
On the following page is an Excel worksheet showing the calculation for the levelized annual replacement cost savings.

Calculation of O&M Impact for Baseline

Measure Life	8
Real Discount Rate (RDR	5.00%

	Bulb Assumptions	
	Inc	Halogen
Component 1 Life (years)	1	3
Component 1 Replacement Cost	$0.50	$2.00

$0.00

2012		NPV	2012	2013	2014	2015	2016	2017	2018	2019
		Year								
21W+	Baseline Replacement Costs	$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00
16-20W	Baseline Replacement Costs	$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00	$2.00
15W and less	Baseline Replacement Costs	$3.86	$0.00	$0.50	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.97	$4.97
16-20W	$4.97	$4.97
15W and less	$3.86	$4.97

Multiply by 0.89 ISR

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.42	$4.42
16-20W	$4.42	$4.42
15W and less	$3.44	$4.42

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Residential LED Lamps

Official Measure Code: Res-Ltg-LED-1

Description

A low wattage ENERGY STAR qualified LED screw-in lamp is installed in place of an incandescent screw-in lamp. The incremental cost of the LED compared to the incandescent lamp is offset via either rebate coupons or via upstream markdowns.

Definition of Efficient Equipment

In order for this characterization to apply, the high-efficiency equipment must be an ENERGY STAR qualified LED lamp.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be an incandescent lamp, with adjustments to baseline lamp watts made during lifecycle of LED replacement lamp.

Deemed Calculation for this Measure

Annual kWh Savings $= (Watt_{Base} - Watt_{LED}) * 0.979$

Summer Coincident Peak kW Savings $= (Watt_{Base} - Watt_{LED}) * 0.000116$

Annual MMBtu $= (Watt_{Base} - Watt_{LED}) * (-0.00187)$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is

Screw-in LED lamps - 15 years

Deemed Measure Cost

The incremental cost for this measure is assumed to be

LED lamps cost $70 on average[25].

[25] Duke Energy workpapers produced by Franklin Energy Systems (FES). FES-L6B LED Lighting Duke Midwest 09012011.

Deemed O&M Cost Adjustments

Baseline lamp replacement costs must be adjusted based on baseline lamp phase-out schedule. Incandescent and halogen (conforming to lamp efficiency regulations) cost assumptions are shown below.

	Standard Incandescent	Halogen
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	1[26]	3[27]

Coincidence Factor

The summer peak coincidence factor for this measure is 0.11[28].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = ((Watt_{Base} - Watt_{LED})/1000) * ISR * HOURS * (1+WHF_e)$$

Where:

$Watt_{Base}$ = Baseline lamp Watts
$Watt_{LED}$ = LED lamp Watts
ISR = In Service Rate or percentage of units rebated that get installed.
= 1.0[29]
HOURS = Average hours of use per year
= 1040 (2.85 hrs per day)[30]
WHF_e = Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.

[26] Assumes rated life of incandescent bulb of approximately 1000 hours.
[27] Best estimate of future technology from Ohio TRM.
[28] Nexus Market Research, RLW Analytics and GDS Associates study; “New England Residential Lighting Markdown Impact Evaluation, January 20, 2009”
[29] No research currently exists on ISR for LED lamps. An ISR of 1.0 is assigned until research results are available.
[30] Based on weighted average daylength adjusted hours from Duke Energy, June 2010; “Ohio Residential Smart Saver CFL Program”

Incandescent lamp watts and LED lamp equivalents are shown in the Table below[31]:

Incandescent lamp (watts)	Minimum Initial Light Output of LED Lamp (lumens)	Nominal Wattage of LED Lamp Replacement (watts)
25	200	6
35	325	7
40	450	8.7
60	800	13
100	1,600	21.8

For example, a 12 watt LED bulb installed in 2012 using Statewide average for HVAC interactive effects:

$$\Delta kWh = ((60 - 12)/1000) * 1.0 * 1040 * (1 - 0.059)$$
$$= 47 \text{ kWh}$$

Baseline Adjustment

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[32]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the baseline lamp watts must be reduced. In addition, since during the lifetime of an LED, the baseline incandescent lamp will be replaced multiple times, the annual savings claim must be reduced within the life of the measure.

The change to the baseline watts resulting from the legislation are shown below:

Year	Current Typical Incandescent Lamp Watts	Rated Lumen Range	Maximum lamp watts
2012	100	1490 - 26000	72
2013	75	1050 - 1489	53
2014	60	750 - 1049	43
2014	40	310 - 749	29

Summer Coincident Peak Demand Savings

$$\Delta kW = ((Watt_{Base} - Watt_{LED})/1000) * ISR * CF * (1+WHF_d)$$

[31] LED lamp equivalencies from SDGE workpaper on LED A-lamp measures. See Workpaper WPSDGENRLG0106, 2-17-2012.

[32] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.11

For example, a 12 watt LED bulb installed in 2012 using Statewide average for HVAC interactive effects:

$$\Delta kW = ((60 - 12)/1000) * 1.0 * .11 * (1 + 0.057)$$

$$= 0.0055 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBTU_{WH} = ((Watt_{Base} - Watt_{LED})/1000) * ISR * HOURS * WHF_g$$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

For example, a 12 watt LED bulb installed in 2012 using Statewide average HVAC interactive effects:

$$\Delta MMBTU_{WH} = ((60 - 12)/1000) * 1.0 * 1040 * -0.0018$$

$$= - 0.090 \text{ MMBtu}$$

Water Impact Description and Calculation

None

Deemed O&M Cost Adjustment Calculation

In order to account for the shift in baseline due to the Federal Legislation discussed above, the baseline replacement cost over the lifetime of the LED must be calculated. The assumptions used in this calculation are documented below:

	Standard Incandescent	Halogen
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	1[33]	3[34]

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[33] Assumes rated life of incandescent bulb of approximately 1000 hours.
[34] Best estimate of future technology from Ohio TRM.

LED Night Lights

Official Measure Code: Res-Ltg-NiteLite-1

Description

This section addresses night lights with an LED light source replacing an incandescent night light

Definition of Efficient Equipment

LED night light

Definition of Baseline Equipment

Incandescent night light

Deemed Calculation for this Measure

Annual kWh Savings	= 13.6 kWh
Summer Coincident Peak kW Savings	= 0
Annual MMBtu	= 0

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 16 years[35].

Deemed Measure Cost

The first cost for this measure is assumed to be $3.00[36]

Deemed O&M Cost Adjustments

None

Coincidence Factor

The summer peak coincidence factor for this measure is 0.00[37].

REFERENCE SECTION

Calculation of Savings

Energy Savings

[35] Duke Energy workpapers produced by Franklin Energy Systems (FES). FES-L6a LED and Specialty Lighting – Residential. 7-1-2010.
[36] Ibid.
[37] Ibid.

ΔkWh = ((Watt$_{Base}$ - Watt$_{LED}$)/1000) * ISR * HOURS

Where:

Watt $_{Base}$ = Incandescent night light Watts
= 5 watts[38]
Watt$_{LED}$ = LED night light Watts
= 0.33 Watts[39]
ISR = In Service Rate or percentage of units rebated that get installed.
= 1.0[40]
HOURS = Average hours of use per year
= 2920 (8 hrs per day)[41]

LED night light savings are calculated as follows:

ΔkWh = ((5-0.33)/1000) * 1.0 * 2920
= 13.6 kWh

Summer Coincident Peak Demand Savings

None

Fossil Fuel Impact Descriptions and Calculation

None

Water Impact Description and Calculation

None

Deemed O&M Cost Adjustment Calculation

None

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38 Duke Energy workpapers produced by Franklin Energy Systems (FES). FES-L6a LED and Specialty Lighting – Residential. 7-1-2010.
39 Ibid
40 No research currently exists on ISR for LED night lights. An ISR of 1.0 is assigned until research results are available.
41 Duke Energy workpapers produced by Franklin Energy Systems (FES). FES-L6a LED and Specialty Lighting – Residential. 7-1-2010.

Refrigerator and/or Freezer Retirement (Early Retirement)

Official Measure Code: Res-Appl-Refrig/Freez-Recycle-1

Description

This measure involves the removal of an existing inefficient primary or secondary refrigerator or freezer from service, prior to its natural end of life (early retirement) [42]. The program should target units with an age greater than 10 years, though it is expected that the average age will be greater than 20 years based on other similar program performance. Savings are calculated for the estimated energy consumption during the remaining life of the existing unit.

Definition of Efficient Equipment

n/a

Definition of Baseline Equipment

In order for this characterization to apply, the existing inefficient unit must be in working order and be removed from service.

Deemed Savings for this Measure

	Average Annual KWH Savings per unit	Average Summer Coincident Peak kW Savings per unit
Refrigerator	1036	0.149
Freezer	942	0.133

Deemed Measure Life

The remaining useful life of the retired unit is assumed to be 8 Years [43].

Deemed Measure Cost

The incremental cost for this measure will be the actual cost associated with the removal and recycling of the retired unit.

Deemed O&M Cost Adjustments

n/a

[42] This measure assumes a mix of primary and secondary units will be replaced (and the savings are reduced accordingly). By definition, the refrigerator in a household's kitchen that satisfies the majority of the household's demand for refrigeration is the primary refrigerator. One or more additional refrigerators in the household that satisfy supplemental needs for refrigeration are referred to as secondary refrigerators.
[43] KEMA "Residential refrigerator recycling ninth year retention study", 2004

Coincidence Factor

A coincidence factor is not used to calculate peak demand savings for this measure. See discussion below.

REFERENCE SECTION

Calculation of Savings

Energy Savings

Refrigerators:

$$\Delta kWh = UEC_{retired} * F_{runtime}$$

$UEC_{retired}$[44] $= 365.25*(Intercept + (C_{age} * Age) + (C_{before90} * F_{before90}) + C_{size} * Size + (C_{singledoor} * F_{singledoor}) + (C_{sidebyside} * F_{sidebyside}) + (C_{primary} * F_{primary}) + (C_{CDD,outdoor} * CDD * F_{outdoor}) + (C_{HDD,outdoor} * HDD * F_{outdoor}))$

Where:

$UEC_{retired}$ = Average in situ Unit Energy Consumption of retired unit
$F_{runtime}$ = run time adjustment factor
Intercept = regression model intercept
C_{age} = Age coefficient
Age = unit age (yr)
$C_{before90}$ = Manufactured before 1990 coefficient
$F_{before90}$ = Fraction of units manufactured before 1990
C_{size} = Size coefficient
Size = unit size (cubic feet)
$C_{singledoor}$ = Single door coefficient
$F_{singledoor}$ = Fraction of units that are single door
$C_{sidebyside}$ = Side by side coefficient
$F_{sidebyside}$ = Fraction of units that are side by side
$C_{primary}$ = Primary use coefficient
$F_{primary}$ = Fraction of units that are primary use
$C_{CDD,outdoor}$ = Cooling degree day x Fraction outdoor coefficient
CDD = Local cooling degree-days per day
$F_{outdoor}$ = Fraction of units that are located in garages or outdoors
$C_{HDD,outdoor}$ = Heating degree day x Fraction outdoor coefficient
HDD = Local heating degree-days per day

[44] Regression model developed by Cadmus Group for the 2006-2008 California Appliance Recycling Program evaluation. See The Cadmus Group, Inc. 2010. "Residential Retrofit High Impact Measure Evaluation Report." (http://www.calmac.org/publications/FinalResidentialRetroEvaluationReport_11.pdf).

Regression model coefficients[45] are listed below:

Independent Variables	Coefficient	p-Value	VIF
Intercept	0.769	<.0001	0
Age (years)	0.008	0.016	2
Dummy: Unit Manufactured Pre-1990	0.827	<.0001	1.7
Size (cubic feet)	0.083	<.0001	1.9
Dummy: Single Door	-1.316	<.0001	1.3
Dummy: Side-by-Side	0.862	<.0001	1.6
Dummy: Primary Appliance	0.642	<.0001	1.5
Interaction: CDD x Dummy: in Garage	0.031	<.0001	1.3
Interaction: HDD x Dummy: in Garage	-0.049	<.0001	1.2

For example, refrigerator model parameters derived for the NIPSCO Appliance Recycling program[46] are shown below:

Parameter	Value
Age	18.78
Before 1990	0.27
Size	20.17
Single door	0.11
Side by side	0.13
Primary use	0.33
CDD	2.225
HDD	17.244
Outdoor	0.62
Run-time adjustment	0.828

Refrigerator ΔkWh = 947 kWh

Freezers:

$$UEC_{retired}{}^{47} = 365.25*(Intercept + (C_{age} * Age) + (C_{before90} * F_{before90}) + (C_{size} * Size) + (C_{chest} * F_{chest}) + (C_{CDD,outdoor} * CDD * F_{outdoor}) + (C_{HDD,outdoor} * HDD * F_{outdoor}))$$

[45] Model estimated by Cadmus Group for Vectren from monitored data in CA and Michigan.
[46] Evaluation of the NIPSCO Appliance Recycling Program. TecMarket Works 2012.
[47] Regression model developed by Cadmus Group for the 2006-2008 California Appliance Recycling Program evaluation. See The Cadmus Group, Inc. 2010. "Residential Retrofit High Impact Measure Evaluation Report." (http://www.calmac.org/publications/FinalResidentialRetroEvaluationReport_11.pdf).

Where:

C_{chest} = Chest freezer coefficient
F_{chest} = Fraction of units that are chest freezers

Regression model coefficients[48] are listed below:

Independent Variables	Coefficient	p-Value	VIF
Intercept	-0.372	0.043	0
Age (years)	0.036	<.0001	2
Dummy: Unit Manufactured Pre-1990	0.632	<.0001	2.1
Size (cubic feet)	0.107	<.0001	1.2
Dummy: Chest Freezer	-0.293	<.0001	1.2
Interaction: CDD x Dummy: in Garage	0.047	<.0001	1.1
Interaction: HDD x Dummy: in Garage	-0.052	<.0001	1

This approach was applied to recycling program evaluations for NIPSCO, Vectren and I&M. The unit energy savings values varied across these programs due to variations in the characteristics of the recycled units. The results are shown below:

Utility	Refrigerator (kWh/unit)	Freezer (kWh/unit)
Nipsco	947	886
I&M	1068	946
Vectren	1093	993
Average	1036	942

The TRM will adopt the average of these values as the Statewide savings estimate.

Summer Coincident Peak Demand Savings

$$\Delta kW = (\Delta kWh/8760) * TAF * LSAF$$

Where:

TAF = Temperature Adjustment Factor
= 1.21 [49]
LSAF = Load Shape Adjustment Factor
= 1.074[50]

[48] Model estimated by Cadmus Group for Vectren from monitored data in CA and Michigan.
[49] Temperature adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 85% of homes have air conditioning.
[50] Load Shape adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48).

This approach was applied to recycling program evaluations for NIPSCO, Vectren and I&M. The unit demand savings values varied across these programs due to variations in the characteristics of the recycled units. The results are shown below:

Utility	Refrigerator (kW/unit)	Freezer (kW/unit)
Nipsco	0.151	0.141
I&M	0.126	0.109
Vectren	0.170	0.150
Average	0.149	0.133

The TRM will adopt the average of these values as the Statewide savings estimate.

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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Residential HVAC Maintenance/Tune Up (Retrofit)

Official Measure Code: Res-HVAC-AC/Furn Tuneup-1

Description

This measure involves the measurement of refrigerant charge levels and airflow over the central air conditioning or heat pump unit coil, correction of any problems found and post-treatment re-measurement. Measurements must be performed with standard industry tools and the results tracked by the efficiency program.

Savings from this measure are developed using a reputable Wisconsin study. It is recommended that future evaluation be conducted in Indiana to generate a more locally appropriate characterization.

Definition of Efficient Equipment

n/a

Definition of Baseline Equipment

This measure assumes that the existing unit being regularly maintained is either a residential central air conditioning unit or an air source heat pump.

Deemed Calculation for this Measure

Annual kWh Savings (central air conditioning) $= FLH_{cool} * BtuH * (1/SEER_{CAC}) * 5 * 10^{-5}$

Annual kWh Savings (air source heat pump) $= (FLH_{cool} * BtuH * (1/SEER_{ASHP}) * 5 * 10^{-5}) + (FLHheat * BtuH * (1/HSPF_{ASHP})) * 5 * 10^{-5})$

Summer Coincident Peak kW Savings $= BtuH * (1/EER)) * 4.4 * 10^{-5}$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 5 years[51].

Deemed Measure Cost

If the implementation mechanism involves delivering and paying for the tune up service, the actual cost should be used. If however the customer is provided a rebate and the program relies on private contractors performing the work, the measure cost should be assumed to be $64[52].

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[51] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[52] Survey of Dayton area HVAC contractors gave inspection and tuneup cost of $160, while inspection only costs are $96. Net tuneup cost is $64.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[53].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh_{Central\ AC} = (FLHcool * BtuH * (1/SEER_{CAC}))/1000 * MFe$$

$$\Delta kWh_{Air\ Source\ Heat\ Pump} = ((FLHcool * BtuH * (1/SEER_{ASHP}))/1000 * MFe) + (FLHheat * BtuH * (1/HSPF_{ASHP}))/1000 * MFe)$$

Where:

FLH_{cool} = Full load cooling hours

Dependent on location as below:

Location	FLH_{cool} [54]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

BtuH = Size of equipment in Btuh (note 1 ton = 12,000Btuh)
= Actual

$SEER_{CAC}$ = SEER Efficiency of existing central air conditioning unit receiving maintenance
= Actual[55]

MF_e = Maintenance energy savings factor
= 0.05[56]

53 Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com
54 Based on prototypical building simulations. See Appendix A.
55 Use SEER rating of serviced unit. Preston's Guide can be used to look up SEER data by make and model number for older AC and heat pumps (www.prestonguide.com)... When unknown use SEER 10 (estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006)
56 Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research." Note, MFe for heat pumps is set to MFe for air conditioners, pending EM&V review.

$SEER_{ASHP}$ = SEER Efficiency of existing air source heat pump unit receiving maintenance
= Actual [57]

FLH_{heat} = Full load heating hours

Dependent on location as below:

Location	FLH_{heat} [58]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

$HSPF_{base}$ = Heating Season Performance Factor of existing air source heat pump unit receiving maintenance
= Actual[59]

For example, maintenance of a 3-ton, SEER 10 air conditioning unit in Indianapolis:

$$\Delta kWh_{CAC} = (487 * 36000 * (1/10))/1000 * 0.05$$

$$= 88 \text{ kWh}$$

For example, maintenance of a 3-ton, SEER 10, HSPF 6.8 air source heat pump unit in Indianapolis:

$$\Delta kWh_{ASHP} = ((487 * 36000 * (1/10))/1000 * 0.05) + (1341 * 36000 * (1/6.8))/1000 * 0.05)$$

$$= 443 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = BtuH * (1/EER)/1000 * MF_d * CF$$

Where:

EER = EER Efficiency of existing unit receiving maintenance
= Calculate using Actual SEER
= (SEER * 0.9)[60]

[57] Use SEER rating of serviced unit. When unknown use SEER 10 (estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006)
[58] Heating EFLH extracted from simulations. See Appendix B.
[59] Use actual HSPF rating where it is possible to measure or reasonably estimate. When unknown use HSPF 6.8 (Minimum Federal Standard between 1992 and 2006).
[60] If SEER is unknown, default EER would be (10 * 0.9) = 9.0. Calculation based on assessment of industry equipment efficiency ratings.

MF_d	= Maintenance demand savings factor = 0.05[61]
CF	= Summer Peak Coincidence Factor for measure = 0.88[62]

For example, maintenance of 3-ton, SEER 10 (equals EER 9.0) unit:

$$\Delta kW = 36000 * 1/(9.0)/1000 * 0.05 * 0.88$$

$$= 0.176 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

Conservatively not included

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[61] Data are sparse for this parameter. Set equal to MFe, subject to EM&V review.
[62] Duke Energy data for residential AC loads.

Residential Boiler Tune-Up

Official Measure Code: Res-HVAC-Boiler Tuneup-1

Description

This section covers tune-ups of existing residential boilers to improve the seasonal heating efficiency.

Definition of Efficient Equipment

Boiler after tuneup is performed

Definition of Baseline Equipment

Existing boiler before tune-up

Deemed Calculation for this Measure

Annual MMBtu Savings = FLH_{HEAT} * BtuH * 0.05 * 10^{-6}

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $140 per boiler.

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

N/A

REFERENCE SECTION

Calculation of Savings

Fossil Fuel Impact Descriptions and Calculation

Annual MMBtu Savings = FLH_{HEAT} * BtuH * ESF * 10^{-6}

Where:

BtuH = Size of equipment in Btuh input capacity
= Actual installed

FLH_{HEAT} = Equivalent Full Load Heating Hours
= see Table below:

Location	FLH_{heat}[63]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

ESF = energy savings factor
= 0.05[64]

For example: Energy savings from a tune-up of a 100 kBtu/hr boiler installed in Indianapolis is calculated as follows:

Annual MMBtu Savings = FLH_{HEAT} * BtuH * ESF * 10^{-6}
= 1341 * 100,000 * 0.05 * 10^{-6}
= 6.7 MMBtu per year

Water Impact Description and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

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Referenced Documents:

[63] Heating EFLH extracted from simulations. See Appendix B.
[64] Energy savings of 5% for residential boiler tuneups are used in the Michigan Efficiency Measures Database.

Attic/Roof/Ceiling Insulation (Retrofit)

Official Measure Code: Res-Shell-RoofInsul-1

Description

This measure characterization is for the installation of new additional insulation in the attic/roof/ceiling of a residential building. The measure assumes that an auditor, contractor or utility staff member is on location, and will measure and record the existing and new insulation depth and type (to calculate R-values), and the surface area of insulation added.

Definition of Efficient Equipment

The new insulation should meet any qualification criteria required for participation in the program. The new insulation R-value should include the effective R-value of any existing insulation that is left in situ. The R-value should also consider installation conditions, such as insulation compression and void fraction.

Definition of Baseline Equipment

The R-value should consider installation conditions, such as insulation compression and void fraction.

Deemed Calculation for this Measure

$$\Delta kWh = kSF \times \Delta kWh/kSF$$

$$\Delta kW_S = kSF \times \Delta kW/kSF \times 0.5$$

$$\Delta MMBTU = kSF \times \Delta MMBTU/kSF$$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 25 years[65].

Deemed Measure Cost

The actual insulation installation measure cost should be used.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[66].

[65] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[66] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = kSF \times \Delta kWh/kSF$$

Where:

kSF = area of installed insulation (1000 sq. ft.)
ΔkWh/kSF = unit energy savings from lookup table

Unit energy savings values are provided for a set of baseline and measure R-values; and HVAC system types. Values are provided for homes with and without cooling, and for homes with gas, heat pump, or electric resistance heating systems. The R-values are for the insulation layer only; R-values of building materials are included in the simulation model. Interpolation within the tables is permissible for R-values not explicitly listed. The baseline and measure R-values should consider installation conditions such as insulation compression and coverage. Insulation compression adjustment factors (Fcomp) are shown below:

% Compression	Fcomp
0%	1.00
5%	0.97
10%	0.93
15%	0.89
20%	0.85

An additional adjustment should be taken for the insulation coverage. This factor (Fvoid) is determined by the installation grade or void fraction; and the ratio of the insulation R-value to the full assembly R-value. The insulation coverage adjustment is shown below:

RmfgxFcomp / Rtotal	Fvoid	
	2% Void (Grade II)	5% Void (Grade III)
0.50	0.96	0.90
0.55	0.96	0.90
0.60	0.95	0.88
0.65	0.94	0.87
0.70	0.94	0.85
0.75	0.92	0.83
0.80	0.91	0.79
0.85	0.88	0.74
0.90	0.83	0.66
0.95	0.71	0.49
0.99	0.33	0.16

The adjusted R-value is the nominal R-value times the adjustment factors:

$$Radj = Rnominal \times Fcomp \times Fvoid$$

For example, 2000 square feet of attic floor insulation is installed in an average Indianapolis home. The home started with uncompressed R-11 insulation with a 5% void fraction. The final R-value (including the original insulation) is R-38, with a 2% void fraction. The building materials and attic air space represent an additional R-5.

Initial Adjusted R-value calculation

RmfgxFcomp / Rtotal = 11 x 1 / (11 + 5)

= 0.69

F_{void} (from Table) = 0.85

The adjusted initial R-value is:

Radj = Rnominal x Fcomp x Fvoid
= 11 x 1 x .85
= 9.4

Final Adjusted R-value calculation

RmfgxFcomp / Rtotal = 38 x 1 / (38 + 5)

= 0.88

F_{void} (from Table) = 0.69 (interpolated)

The adjusted final R-value is:

Radj = Rnominal x Fcomp x Fvoid
= 38 x 1 x .69
= 26

Interpolating from the Table at the end of this section:

ΔkWh = kSF x ΔkWh/kSF

= 2 x 593
= 1,187 kWh

Summer Coincident Peak Demand Savings

ΔkW_S = kSF x ΔkW/kSF x CF

Where:

ΔkW/kSF = unit demand savings from lookup table

CF = Summer Peak Coincidence Factor for measure
= 0.88 [67]

Using the values from the example above and interpolating the kW/kSF value from the Table below:

ΔkW_S = kSF x ΔkW/kSF x CF

= 2 x 0.088 x 0.88
= 0.155 kW

Space Heating Savings Calculation

ΔMMBTU = kSF x ΔMMBTU/kSF

Where:
ΔMMBTU/kSF = unit fossil fuel energy savings from lookup table

Using the values from the example above and interpolating the kW/kSF value from the Table below:

ΔMMBTU = kSF x ΔMMBTU/kSF
= 2 x 7.2
= 14.4

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
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[67] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com

Reference Tables

Attic/Roof/Ceiling Insulation

Building: Single Family **City: Indianapolis** **HVAC: Weighted Average** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	1932.6	0.1809	23.00												
19	2160.6	0.2289	25.77	228.0	0.0478	2.81									
30	2292.9	0.2508	27.43	360.3	0.0697	4.42	132.3	0.0219	1.67						
38	2342.1	0.2653	28.05	409.6	0.0844	5.03	181.6	0.0364	2.28	49.3	0.0145	0.62			
49	2387.0	0.2690	28.58	454.5	0.0881	5.64	226.6	0.0401	2.83	94.2	0.0182	1.22	44.9	0.0037	0.53
60	2416.8	0.2690	28.96	484.3	0.0881	5.95	256.3	0.0401	3.19	124.0	0.0182	1.53	74.7	0.0037	0.91

Building: Single Family **City: South Bend** **HVAC: Weighted Average** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	1906.0	0.0911	23.16												
19	2132.2	0.1200	25.98	226.2	0.0289	2.83									
30	2260.9	0.1375	27.59	354.9	0.0464	4.50	128.7	0.0175	1.67						
38	2310.2	0.1382	28.26	404.2	0.0471	5.11	178.0	0.0182	2.29	49.4	0.0007	0.62			
49	2354.6	0.1413	28.81	448.5	0.0502	5.65	222.4	0.0213	2.83	93.7	0.0037	1.22	44.4	0.0031	0.61
60	2383.5	0.1413	29.19	477.5	0.0502	6.02	251.2	0.0213	3.21	122.5	0.0037	1.60	73.2	0.0031	0.91

Building: Single Family **City: Evansville** **HVAC: Weighted Average** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	1604.1	0.3766	18.44												
19	1797.8	0.4358	20.80	193.8	0.0585	2.29									
30	1908.9	0.4755	22.11	304.9	0.0981	3.66	111.2	0.0396	1.37						
38	1951.6	0.4900	22.64	347.6	0.1132	4.19	153.8	0.0541	1.90	42.6	0.0145	0.53			
49	1988.5	0.5014	23.09	384.5	0.1246	4.65	190.8	0.0655	2.36	79.6	0.0258	0.99	36.9	0.0114	0.46
60	2012.6	0.5152	23.40	408.6	0.1386	4.95	214.8	0.0792	2.66	103.7	0.0396	1.29	61.0	0.0252	0.76

Building: Single Family				City: Ft Wayne		HVAC: Weighted Average				Measure: Roof Insulation					
Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	1955.3	0.1406	24.32												
19	2183.8	0.1695	27.27	228.4	0.0289	2.96									
30	2315.6	0.1977	28.96	360.2	0.0571	4.64	131.8	0.0282	1.75						
38	2368.3	0.1977	29.64	413.0	0.0571	5.32	184.5	0.0282	2.43	52.7	0.0000	0.68			
49	2414.1	0.2114	30.25	458.8	0.0709	5.93	230.3	0.0420	2.98	98.6	0.0138	1.29	45.9	0.0138	0.61
60	2443.1	0.2121	30.63	487.8	0.0716	6.31	259.4	0.0427	3.36	127.6	0.0145	1.67	74.9	0.0145	0.99

Building: Single Family				City: Terre Haute		HVAC: Weighted Average				Measure: Roof Insulation					
Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	1963.4	0.1598	24.24												
19	2194.9	0.1743	27.21	231.5	0.0145	2.96									
30	2328.8	0.1887	28.96	365.3	0.0289	4.71	133.8	0.0145	1.75						
38	2382.7	0.2032	29.64	419.3	0.0434	5.40	187.7	0.0289	2.43	53.9	0.0145	0.68			
49	2425.8	0.2032	30.25	462.4	0.0434	6.00	230.9	0.0289	3.04	97.1	0.0145	1.29	43.2	0.0000	0.61
60	2456.3	0.2038	30.63	492.9	0.0440	6.38	261.4	0.0296	3.42	127.6	0.0151	1.67	73.7	0.0007	0.99

ENERGY STAR Torchiere (Time of Sale)

Official Measure Code: Res-Ltg-Torchiere-1

Description

A high efficiency ENERGY STAR fluorescent torchiere is purchased in place of a baseline mix of halogen and incandescent torchieres and installed in a residential setting. Assumptions are based on a time of sale purchase, not as a retrofit or direct install installation.

Definition of Efficient Equipment

To qualify for this measure the fluorescent torchiere must meet ENERGY STAR efficiency standards.

Definition of Baseline Equipment

The baseline is based on a mix of halogen and incandescent torchieres.

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Residential	113	0.013	- 0.22	n/a

Deemed Lifetime of Efficient Equipment

The lifetime of the measure is assumed to be 7 years[68].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $5.00[69].

Deemed O&M Cost Adjustments

The annual O&M Cost Adjustment savings is calculated as $2.52.

Coincidence Factor

The summer peak coincidence factor for this measure is 0.11[70].

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[68] Energy Star value for this measure. See www.energystar.gov.
[69] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
[70] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

Calculation of Savings

Energy Savings

$\Delta kWh = ((\Delta Watts_{Torch} / 1000) * ISR * HOURS * (1+WHF_e))$

Where:

$\Delta Watts_{Torch}$ = Average delta watts per purchased ENERGY STAR torchiere
= 115.8[71]

ISR = In-service Rate or percentage of units rebated that get installed.
= 0.95 [72]

HOURS = Average hours of use per year
= 1095 (3.0 hrs per day)[73]

WHF_e = Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.

For example, an ENERGY STAR torchiere using Statewide average HVAC interactive effects:

$\Delta kWH = ((115.8 /1000) * 0.95 * 1095 * (1 - 0.059))$

$= 113$ kWh

Summer Coincident Peak Demand Savings

$\Delta kW = ((\Delta\ Watts_{Torch} /1000) * ISR * (1 + WHF_d) * CF)$

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.11[74]

[71] Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 43 (Table 4-9)

[72] Nexus Market Research, RLW Analytics "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs" table 6-3 on p63 indicates that 86% torchieres were installed and a further 9% were to be installed. Table6-7 on p67 shows that none are purchased as spares so we assume that all are installed in first year.
(http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtreportfinal100104.pdf)

[73] Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 104 (Table 9-7)

[74] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

For example, an ENERGY STAR torchiere using Statewide average HVAC interactive effects:

$$\Delta kW = ((115.8 /1000) * 0.95 * (1 + 0.057) * 0.11)$$

$$= 0.013 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBTU_{WH} = ((\Delta Watts_{Torch} /1000) * ISR * HOURS * WHF_g)$$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

For example, an ENERGY STAR torchiere using Statewide average HVAC interactive effects:

$$\Delta MMBTU_{WH} = ((115.8/1000) * 0.95 * 1095 * -0.0018$$

$$= - 0.\ 22 \text{ MMBtu}$$

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

The annual O&M Cost Adjustment savings is calculated as $2.52, based on the following component costs and lifetimes[75]

	Efficient Measure		Baseline Measures	
Component	Cost	Life (yrs)	Cost	Life (yrs)
Lamp	$7.50	8.87 years[76]	$6.00	1.83 years[77]

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[75] Cost data derived from Efficiency Vermont TRM.
[76] Calculated using assumed average rated life of Energy Star compact fluorescent torchiere bulbs of 9710 hours (9710/1095= 8.87 years) (http://downloads.energystar.gov/bi/qplist/fixtures_prod_list.xls).
[77] Based on assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours.

Dedicated Pin Based Compact Fluorescent Lamp (CFL) Table Lamp (Time of Sale)

Official Measure Code: Res-Ltg-CFLTable-1

Description

A dedicated pin based low wattage compact fluorescent (CFL) table lamp is purchased through a retail outlet in place of an equivalent incandescent bulb lamp. The incremental cost of the CFL lamp compared to an incandescent lamp is offset via either rebate coupons or via upstream markdowns. Assumptions are based on a time of sale purchase, not as a retrofit or direct install installation. This characterization assumes that the CFL is installed in a residential location.

Definition of Efficient Equipment

In order for this characterization to apply, the high-efficiency equipment must be dedicated pin based low wattage compact fluorescent (CFL) table lamp.

Definition of Baseline Equipment

The baseline equipment is an incandescent table lamp.

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Residential	38.7	0.0053	- 0.074	n/a

Adjustment to annual savings within life of measure:

CFL Wattage	Delta Watts Multiplier[78]		
	2012	2013	2014 and Beyond
15 or less	3.25	3.25	2.05
16-20	3.25	2.00	2.00
21W+	2.06	2.06	2.06

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 8 years[79].

[78] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).
[79] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Measure Cost

The incremental cost for this measure is assumed to be $8[80].

Deemed O&M Cost Adjustments

The calculated levelized annual replacement cost savings for CFL type and installation year are presented below:

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.97	$4.97
16-20W	$4.97	$4.97
15W and less	$3.86	$4.97

Coincidence Factor

The summer peak coincidence factor for this measure is 0.11[81].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = ((ΔWatts) /1000) * ISR * HOURS * (1 + WHF_e)

Where:

ΔWatts = Difference in wattage between CFL and incandescent bulb
= 45.7 [82]

ISR = In Service Rate or percentage of units rebated that get installed.
= 1.0 [83]

HOURS = Average hours of use per year
= 901 [84]

WHF_e = Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.

For example, a CFL table lamp using Statewide average HVAC interactive effects:

ΔkWh = (45.7 / 1000) * 1.0 * 901 * (1 – 0.059)

= 38.7 kWh

[80] Average table lamp measure in DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
[81] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"
[82] Based on RLW Analytics, New England Residential Lighting Markdown Impact Evaluation, January 20, 2009.
[83] Estimate of Service Rates of table lamps, assuming people purchasing a table lamp will install and use it.
[84] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009", p50.

Summer Coincident Peak Demand Savings

$$\Delta kW = ((\Delta Watts) /1000) * ISR * (1+WHF_d) * CF$$

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.11

For example, a CFL table lamp using Statewide average HVAC interactive effects:

$$\Delta kW = (45.7 / 1000) * 1.0 * (1 + 0.067) * 0.11 = 0.0053 \text{ kW}$$

Baseline Adjustment

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[85]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. For example, for 100W equivalent bulbs (21W+ CFLs) installed in 2010, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[86]:

85 http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

86 Calculated by finding the percentage reduction in change of delta watts, for example change in 100W bulb: (72-23.5)/(100-23.5) = 63.4%

CFL Wattage	Savings as Percentage of Base Year Savings		
	2012	2013	2014 and Beyond
15 or less	100%	100%	63%
16-20	100%	62%	62%
21W+	63%	63%	63%

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBTU_{WH}$ = ((ΔWatts) /1000) * ISR * HOURS * WHF_g

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

For example, a CFL table lamp using Statewide average HVAC interactive effects:

$\Delta MMBTU_{WH}$ = (45.7 / 1000) * 1.0 * 901 * -0.0018

= - 0.074 MMBtu

Deemed O&M Cost Adjustment Calculation

In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated. The key assumptions used in this calculation are documented below:

	Standard Incandescent	Halogen
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	1[87]	3[88]

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

87 Assumes rated life of incandescent bulb of approximately 1000 hours.
88 Best estimate of future technology.

CFL wattage	NPV of baseline Replacement Costs	
	2012	2013 on
21W+	$4.97	$4.97
16-20W	$4.97	$4.97
15W and less	$3.86	$4.97

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Referenced Documents:
On the following page is an Excel file showing the calculation for the levelized annual replacement cost savings.

Calculation of O&M Impact for Baseline

Measure Life	8
Real Discount Rate (RDR	5.00 %

Bulb	
Inc	Haloge
1	3
$0.50	$2.00

Component 1 Life (years) Component 1 Replacement Cost

2012		NPV	2012	2013	2014	2015	2016	2017	2018	2019
21W+	Baseline Replacement Costs $2.00		$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00
16-20W	Baseline Replacement Costs $2.00		$4.97	$0.00	$2.00	$0.00	$0.00	$2.00	$0.00	$0.00
15W and less	Baseline Replacement Costs $0.00		$3.86	$0.00	$0.50	$2.00	$0.00	$0.00	$2.00	$0.00

CFL	NPV of baseline Replacement 2012	2013 on
21W+	$4.97	$4.97
16-20W	$4.97	$4.97
15W and less	$3.86	$4.97

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Ceiling Fan with ENERGY STAR Light Fixture (Time of Sale)

Official Measure Code: Res-Appl-CeilFan-1

Description

This measure describes the installation of an ENERGY STAR ceiling fan that uses a high efficiency motor and contains compact fluorescent bulbs in place of a standard fan with integral incandescent bulbs.

Definition of Efficient Equipment

The efficient equipment must be an ENERGY STAR certified ceiling fan with integral CFL bulbs.

Definition of Baseline Equipment

The baseline equipment is assumed to be a standard fan with integral incandescent bulbs.

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
2010 -2013	169	0.027	- 0.30	n/a
2014 on	108	0.017	- 0.19	n/a

Adjustment to annual savings within life of measure of 64% at 2014.

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 10 years[89].

Deemed Measure Cost

The incremental cost for the ENERGY STAR ceiling fan is $86[89].

Deemed O&M Cost Adjustments

The calculated net present value of the baseline replacement costs minus the CFL replacement cost for each installation year are presented below. Note this is per fan (i.e. 3 bulbs):

[89] ENERGY STAR Ceiling Fan Savings Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Ceiling_Fan_Savings_Calculator_Consumer.x ls)

NPV of baseline Replacement Costs - CFL Replacement Costs	
2012	2013 on
$8.17	$7.45

Coincidence Factor

The summer peak coincidence factor for this measure is 0.11[90].

REFERENCE SECTION

Calculation of Savings

Energy Savings

Where [91]:

$$\Delta kWh = ((\%_{low} * (LowKW_{base} - LowKW_{ee}) + \%_{med} * (MedKW_{base} - MedKW_{ee}) + \%_{high} * (HighKW_{base} - HighKW_{ee})) * HOURS_{fan}) + ((IncKW - CFLKW) * HOURS_{light} * (1 + WHF_{e}))$$

$\%_{low}$	= Percent of time on Low Speed	= 40%
$\%_{med}$	= Percent of time on Medium Speed	= 40%
$\%_{high}$	= Percent of time on High Speed	= 20%
$LowWatt_{base}$	= Low speed baseline ceiling fan wattage	= 0.0152kW
$LowWatt_{ee}$	= Low speed ENERGY STAR ceiling fan wattage	= 0.0117kW
$MedWatt_{base}$	= Medium speed baseline ceiling fan wattage	= 0.0348kW
$MedWatt_{ee}$	= Medium speed ENERGY STAR ceiling fan wattage	= 0.0314kW
$HighWatt_{base}$	= High speed baseline ceiling fan wattage	= 0.0725kW
$HighWatt_{ee}$	= High speed ENERGY STAR ceiling fan wattage	= 0.0715kW
$HOURS_{fan}$	= Typical fan operating hours (2.8/day , 365 days per year) = 1022 hours	
IncWatt	= Incandescent bulb kW (assumes 3 * 60W bulb)	= 0.180kW
CFLWatt	= CFL bulb kW (assumes 3 * 14W bulb)	= 0.042kW
$HOURS_{light}$	= Typical lighting operating hours (3.5/day, 365 days per year) = 1277.5 hours	
WHF_{e}	= Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.	

[90] Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009"

[91] All data points (unless otherwise noted) come from the ENERGY STAR Ceiling Fan Savings Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Ceiling_Fan_Savings_Calculator_Consumer.x ls)

For example, an ENERGY STAR ceiling fan using Statewide average HVAC interactive effects:

$$\Delta kWh = ((0.4 * (0.0152 – 0.0117) + 0.4 * (0.0348 – 0.0314) + 0.2 * (0.0725 – 0.0715)) * 1022) + ((0.18 – 0.042) * 1277.5 * (1 - 0.059))$$

$$= 169 \text{ kWh}$$

Baseline Adjustment

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, first year annual savings for this measure must be reduced beginning in 2014. This measure assumes 60W baseline bulbs, which in 2014 will become 43W and so the annual savings beginning in 2014 for the fan using Statewide average HVAC interactive effects should therefore be:

$$\Delta kWh = ((0.4 * (0.0152 – 0.0117) + 0.4 * (0.0348 – 0.0314) + 0.2 * (0.0725 – 0.0715)) * 1022) + ((0.129 – 0.042) * 1277.5 * (1- 0.059))$$

$$= 108 \text{ kWh}$$

In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. Therefore, for bulbs installed in 2010, the full savings (169 kWh) should be claimed for the first four years, but the reduced annual savings (108 kWh) claimed for the remainder of the measure life. The savings adjustment is therefore equal to 108/169 = 64%.

Summer Coincident Peak Demand Savings

$$\Delta kW = (\%_{low} * (LowKW_{base} - LowKW_{ee}) + \%_{med} * (MedKW_{base} - MedKW_{ee}) + \%_{high} * (HighKW_{base} - HighKW_{ee})) + ((IncKW – CFLKW) * (1+WHF_d)) * CF$$

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure = 0.18

For example, an ENERGY STAR ceiling fan using Statewide average HVAC interactive effects:

ΔkW = ((0.4 * (0.0152 – 0.0117) + 0.4 * (0.0348 – 0.0314) + 0.2 * (0.0725 – 0.0715))+ ((0.18 – 0.042) * (1 + 0.057)) * 0.18

ΔkW = 0.027 kW

After 2014, this will be reduced to:

ΔkW = ((0.4 * (0.0152 – 0.0117) + 0.4 * (0.0348 – 0.0314) + 0.2 * (0.0725 – 0.0715)) + ((0.129 – 0.042) * (1 + 0.067)) * 0.18

ΔkW = 0.017 kW

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBTU_{WH}$ = $\Delta kWh * WHF_g$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

$\Delta MMBTU_{WH}$ = 169 * -0.0018

= - 0.30 MMBtu

After 2014, this will be reduced to:

$\Delta MMBTU_{WH}$ = 108 * -0.0018

= - 0.19 MMBtu

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation
In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated. The key assumptions used in this calculation are documented below:

	Standard Incandescent	Efficient Incandescent
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	1[92]	3[93]

The calculated net present value of the baseline replacement costs minus the CFL replacement cost for each installation year are presented below. Note this is per fan (i.e. 3 bulbs):

NPV of baseline Replacement Costs - CFL Replacement Costs	
2012	2013 on
$8.17	$7.45

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Referenced Documents:
On the following page is an embedded Excel worksheet showing the calculation for the levelized annual replacement cost savings. Double click on the worksheet to open the file and review the calculations.

[92] Assumes rated life of incandescent bulb of approximately 1000 hours
[93] Best estimate of future technology.

Calculation of O&M Impact for Baseline

NPV of baseline Replacement Costs - CFL Replacement Costs	
2012	2013 on
$2.72	$2.48

* 3 bulbs

NPV of baseline Replacement Costs - CFL Replacement Costs	
2012	2013 on
$8.17	$7.45

Efficient Refrigerator – ENERGY STAR and CEE TIER 2 (Time of Sale)

Official Measure Code: Res-Appl-Refrig/Freez-TOS-1

Description

This measure relates to the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications (defined as requiring >= 20% or >= 25% less energy consumption than an equivalent unit meeting federal standard requirements respectively). This is a time of sale measure characterization.

Definition of Efficient Equipment

The efficient condition is a new refrigerator meeting either the ENERGY STAR or CEE TIER 2 efficiency standards.

Definition of Baseline Equipment

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency.

Deemed Savings for this Measure

Efficiency Level	Refrigerator Configuration	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
ENERGY STAR	Bottom Freezer	119	0.021	n/a	n/a
	Top Freezer	100	0.018		
	Side by Side	142	0.025		
CEE TIER 2	Bottom Freezer	149	0.026	n/a	n/a
	Top Freezer	124	0.022		
	Side by Side	177	0.031		

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 17 Years [94].

Deemed Measure Cost

The incremental cost for this measure is assumed to be \$30[95] for an ENERGY STAR unit and \$140[96] for a CEE Tier 2 unit.

[94] Consistent with Efficiency Vermont and New Jersey TRMs

[95] From ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls

[96] Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in Department of Energy, "TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers", October 2005;http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

A coincidence factor is not used to calculate peak demand savings for this measure. See discussion below.

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = $UEC_{BASE} - UEC_{EE}$

Where:

UEC_{BASE} = Annual Unit Energy Consumption of baseline unit[97]
Bottom Freezer = 596 kWh
Top Freezer = 497 kWh
Side by Side = 706 kWh

UEC_{EE} = Annual Unit Energy Consumption of ENERGY STAR unit (20% less) Bottom Freezer
= 477 kWh
Top Freezer = 397 kWh
Side by Side = 564 kWh

Or = Annual energy consumption of CEE Tier 2 unit (25% less)
Bottom Freezer = 447 kWh
Top Freezer = 373 kWh
Side by Side = 529 kWh

$\Delta kWh_{\text{ENERGY STAR}}$
Bottom Freezer = 596 – 477
= 119 kWh
Top Freezer = 497 – 397
= 100 kWh
Side by Side = 706 – 564
= 142 kWh

[97] kWh assumptions for base condition are based on the average federal standard baseline usage for the range of efficient units purchased through the Efficiency Vermont's Residential Refrigerator program during 2009.

$\Delta kWh_{CEE\ TIER\ 2}$

Bottom Freezer	= 596 – 447
	= 149 kWh
Top Freezer	= 497 – 373
	= 124 kWh
Side by Side	= 706 – 529
	= 177 kWh

Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh/8760) * TAF * LSAF

Where:

TAF	= Temperature Adjustment Factor
	= 1.21 [98]
LSAF	= Load Shape Adjustment Factor
	= 1.074 [99]

$\Delta kW_{ENERGY\ STAR}$

Bottom Freezer	= 119/8760 * 1.21 * 1.074
	= 0.018 kW
Top Freezer	= 100/8760 * 1.21 * 1.074
	= 0.015 kW
Side by Side	= 142/8760 * 1.21 * 1.074
	= 0.021 kW

$\Delta kW_{CEE\ TIER\ 2}$

Bottom Freezer	= 149/8760 * 1.21 * 1.074
	= 0.022 kW
Top Freezer	= 124/8760 * 1.21 * 1.074
	= 0.018 kW
Side by Side	= 177/8760 * 1.21 * 1.074
	= 0.026 kW

Fossil Fuel Impact Descriptions and Calculation

n/a

[98] Temperature adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 85% of homes have central air conditioning.

[99] Load shape adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48).

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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Refrigerator Replacement (Low Income, Early Replacement)

Official Measure Code: Res-Appl-Refrig-LI-1

Description

This measure describes the early removal of an existing inefficient refrigerator from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. This measure is suitable for a Low Income or Home Performance program. Savings are calculated for the estimated energy consumption during the remaining life of the existing unit.

Definition of Efficient Equipment

The efficient condition is a new replacement refrigerator meeting the ENERGY STAR efficiency standard (defined as requiring >= 20% less energy consumption than an equivalent unit meeting federal standard requirements).

Definition of Baseline Equipment

The baseline condition is the existing inefficient refrigerator for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new refrigerator meeting the minimum federal efficiency standard.

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Remaining life of existing unit (1^{st} 8 years)	1251	0.174	n/a	n/a
Remaining measure life (next 9 years)	112	0.020	n/a	n/a

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 17 Years [100].

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)

The assumed remaining useful life of the existing refrigerator being replaced is 8 Years[101].

[100] Consistent with Efficiency Vermont and New Jersey TRMs
[101] KEMA "Residential refrigerator recycling ninth year retention study", 2004

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 8 years, had the existing unit not been replaced) is calculated as $490.73[102].

Coincidence Factor

A coincidence factor is not used to calculate peak demand savings for this measure. See discussion below.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta\text{kWh for remaining life of existing unit } (1^{st}\text{ 8 years}) = UEC_{existing} - UEC_{ES}$$

$$\Delta\text{kWh for remaining measure life (next 9 years)} = UEC_{base} - UEC_{ES}$$

Where:

$UEC_{existing}$ = Unit Energy Consumption of existing refrigerator
= 1696 kWh [103]

UEC_{ES} = Unit Energy Consumption of new Energy Star refrigerator
= 445 kWh [104]

UEC_{base} = Unit Energy Consumption of new baseline refrigerator
= 557 kWh [105]

ΔkWh = 1251 kWh

[102] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 9 to 17 of a deferred replacement of a standard efficiency unit costing $1150 (from ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls.

[103] Based on regression-based savings estimates and incorporating the part-use factors, from Navigant Consulting, "AEP Ohio Energy Efficiency/Demand Response Plan Year 1 (1/1/2009-12/31/2009) Program Year Evaluation Report: Appliance Recycling Program", March 9, 2010, for primary refrigerator, and multiplied by in situ factor of 0.85 as discussed in Refrigerator Retirement measure.

[104] Approximate average consumption of typical ENERGY STAR refrigerator; http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

[105] Approximate average consumption of typical baseline refrigerator at federal standard efficiency levels; http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel

ΔkWh for remaining measure life (next 9 years) = 557 – 445

= 112 kWh

Summer Coincident Peak Demand Savings

$\Delta kW = (\Delta kWh/8760) * TAF * LSAF$

Where:

TAF = Temperature Adjustment Factor
= 1.21 [106]

$LSAF_{exist}$ = Load Shape Adjustment Factor for existing unit
= 1.074 [107]

$LSAF_{new}$ = Load Shape Adjustment Factor for new unit
= 1.18 [108]

ΔkW for remaining life of existing unit (1st 8 years) = (1696/8760 * 1.21 * 1.074) – (445/8760 * 1.21 * 1.18)

= 0.162 kW

ΔkW for remaining measure life (next 9 years) = 112/8760 * 1.21* 1.18

= 0.019 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 8 years, had the existing unit not been replaced) is calculated as $490.73[109].

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106 Temperature adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 85% of homes have central air conditioning.

107 Daily load shape adjustment factor also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48).

108 Daily load shape adjustment factor also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48, extrapolated by taking the ratio of existing summer to existing annual profile for hours ending 16 through 18, and multiplying by new annual profile.

109 Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 9 to 17 of a deferred replacement of a standard efficiency unit costing $1150 (from ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls).

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Clothes Washer – ENERGY STAR and CEE TIER 3 (Time of Sale)

Official Measure Code: Res-Appl-CloWash-1

Description

This measure relates to the purchase (time of sale) and installation of a clothes washer exceeding either the ENERGY STAR or CEE TIER 2 minimum qualifying efficiency standards presented below:

Efficiency Level	Modified Energy Factor (MEF)	Water Factor (WF)
Federal Standard	>= 1.26	No requirement
ENERGY STAR (as of Jan 1, 2011)	>= 2.0	<= 6.0
CEE TIER 2	>= 2.20	<= 4.5

The modified energy factor (MEF) measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency.

The Water Factor is the number of gallons needed for each cubic foot of laundry. A lower number indicates lower consumption and more efficient use of water.

Definition of Efficient Equipment

The efficient condition is a clothes washer meeting either the ENERGY STAR or CEE TIER 2 efficiency criteria presented above.

Definition of Baseline Equipment

The baseline condition is a clothes washer at the minimum federal baseline efficiency presented above.

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings (gal) per unit
ENERGY STAR	202	0.028	0.447	6,265
CEE TIER 2	233	0.033	0.516	7,160

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 11 years[110].

[110] ENERGY STAR calculator: (http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW)

Deemed Measure Cost

The incremental cost for this measure is assumed to be $258[111] for an ENERGY STAR unit and $372 for a CEE TIER 2 unit[112].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.045[113].

REFERENCE SECTION

Calculation of Savings

Energy Savings

Savings are determined using Modified Energy Factor assumptions, applying the proportion of consumption used for water heating, clothes washer and clothes dryer operation and then to the mix of domestic hot water heating fuels and dryer fuels. Savings from reduced water usage are also factored in.

Key assumptions and their sources are provided below:

Washer Volume	= 3.23 cubic feet [114]
Baseline MEF	= 1.26
ENERGY STAR MEF	= 2.0
CEE TIER 2 MEF	= 2.2
Number of cycles per year	= 320 [115]

% energy consumption for water heating, CW operation, Dryer operation
= 26%, 7%, 67% [116]

[111] ENERGY STAR calculator (as above)
[112] Based on an Efficiency Vermont market field study of incremental clothes washer cost between non-energy star andTier 2 units, finding an average incremental cost to Tier 2 of $371.63.
[113] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York and adjusted for OH peak definitions.
[114] Average unit size from Efficiency Vermont program.
[115] Weighted average of 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division:
(http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc10homeappliaceindicators/pdf/tablehc12.10.pdf)
[116] Based on the Clothes Washer Technical Support Document, Chapter 4, Engineering Analysis, Table 4.1, Page 4-5
http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/chapter_4_engineering.pdf

Average water savings per load [117]

ENERGY STAR	= 19.6 gallons
CEE TIER 3	= 22.4 gallons

Community/Municipal Water and Wastewater pump kWh savings per gallon water saved
= 0.0039kWh per gallon of water save[118]

Indiana DHW fuel mix[119]:

Fuel	% of Homes
Electric	27%
Natural Gas	63%
Other	10%

Indiana Dryer fuel mix[120]:

Fuel	% of Homes
Electric	66%
Natural Gas	34%

$\Delta kWh_{ENERGY\ STAR}$ = 202 kWh

$\Delta kWh_{CEE\ TIER\ 3}$= 233 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh/Hours * CF

Where:

Hours = Assumed Run hours of Clothes Washer
= 320 [121]

CF = Summer Peak Coincidence Factor for measure
= 0.033 [122]

117 Determined starting from gallons per load assumption from the ENERGY STAR calculator, dividing by water factor (gallons per cubic foot) to get cubic feet assumption and multiplying by each efficient case water factor.
118 Efficiency Vermont analysis of Community/Municipal Water and Wastewater pump energy consumption showed 0.0024 kWh pump energy consumption per gallon of water supplied, and 0.0015 kWh consumption per gallon for waste water treatment.
119 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division: (http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc8waterheating/pdf/tablehc12.8.pdf)
120 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division: (http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc9homeappliance/pdf/tablehc12.9.pdf)
121 Based on assumption of 1 hour average per cycle. # cycles based on weighted average of 2005 Residential Energy Consumption Survey (RECS) for East North Central Census Division (see CW Work Sheet). http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc10homeappliaceindicators/pdf/tablehc11.10.pdf
122 Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York and adjusted for OH peak definitions.

$\Delta kW_{ENERGY\ STAR}$ = 202 / 320 * 0.045

= 0.028 kW

$\Delta kW_{CEE\ TIER\ 2}$ = 233 / 320 * 0.045

= 0.033 kW

Fossil Fuel Impact Descriptions and Calculation
Savings are based on the mix of domestic hot water heating fuels and Dryer fuels.

ENERGY STAR unit:
MMBtu Savings Natural Gas = 0.447 MMBtu

CEE TIER 2 unit:
MMBtu Savings Natural Gas = 0.516 MMBtu

Water Impact Descriptions and Calculation

ENERGY STAR unit:
Average Water Savings = 6,265 gallons

CEE TIER 2 unit:
Average Water Savings = 7,160 gallons

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Energy Star Dishwasher

Official Measure Code: Res-Appl-DishWash-1

Description

This section covers residential dishwashers meeting the minimum qualifying efficiency standards established under the Energy Star Program. The dishwashers are assumed to be located within the residential unit, not a commercial dishwasher in a foodservice application.

Definition of Efficient Equipment

New dishwasher meeting Energy Star Tier 2 program requirements (EF >= 0.68).

Definition of Baseline Equipment

New dishwasher meeting minimum Federal Appliance Standards (EF = 0.46).

Deemed Calculation for this Measure

Annual kWh Savings = 77 kWh (gas water heater)
= 150 kWh (electric water heater)

Summer Coincident Peak kW Savings = 0.027 kW (gas water heater)
= 0.052 kW (electric water heater)

Annual MMBtu Savings = 1.3 (gas water heater only)

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 11 years

Deemed Measure Cost

The incremental cost for this measure is assumed to be $211.

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

The summer peak coincidence factor for this measure is 0.1

-

REFERENCE SECTION

Calculation of Savings

Energy Savings

Energy and demand savings for this measure were taken from the EPA Energy Star dishwasher calculator[123].

Annual kWh Savings = 77 kWh (gas water heater)
= 150 kWh (electric water heater)

Summer Coincident Peak kW Savings = 0.027 kW (gas water heater)
= 0.052 kW (electric water heater)

Annual MMBtu Savings = 1.3 (gas water heater only)

Water Impact Description and Calculation

Deemed O&M Cost Adjustment Calculation

N/A

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Referenced Documents:

[123] See www.energystar.gov

ENERGY STAR Dehumidifier (Time of Sale)

Official Measure Code: Res-Appl-ES Dehumid-1

Description

A dehumidifier meeting the minimum qualifying efficiency standard established by ENERGY STAR on 10/1/2006 is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

Definition of Efficient Equipment

To qualify for this measure, the new dehumidifier must meet the ENERGY STAR standards as of 10/1/2006 as defined below:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
≤25	≥1.20
> 25 to ≤35	≥1.40
> 35 to ≤45	≥1.50
> 45 to ≤ 54	≥1.60
> 54 to ≤ 75	≥1.80
> 75 to ≤ 185	≥2.50

Definition of Baseline Equipment

The baseline for this measure is defined as a new dehumidifier that meets the Federal Standard efficiency standards as defined below:

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
≤25	≥1.10
> 25 to ≤35	≥1.20
> 35 to ≤45	≥1.20
> 45 to ≤ 54	≥1.23
> 54 to ≤ 75	≥1.55
> 75 to ≤ 185	≥1.90

Deemed Savings for this Measure

<table>
<tr><th>Capacity Range (pints/day)</th><th>Average Annual kWh Savings per unit</th><th>Average Summer Coincident Peak kW Savings per unit</th><th>Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit</th><th>Average Annual Water savings per unit</th></tr>
<tr><td>≤25</td><td>54</td><td>0.012</td><td rowspan="6">n/a</td><td rowspan="6">n/a</td></tr>
<tr><td>> 25 to ≤35</td><td>117</td><td>0.027</td></tr>
<tr><td>> 35 to ≤45</td><td>213</td><td>0.048</td></tr>
<tr><td>> 45 to ≤ 54</td><td>297</td><td>0.068</td></tr>
<tr><td>> 54 to ≤ 75</td><td>185</td><td>0.042</td></tr>
<tr><td>> 75 to ≤ 185</td><td>374</td><td>0.085</td></tr>
</table>

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 12 years[124]

Deemed Measure Cost

The assumed incremental capital cost for this measure is $45[125]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The coincidence factor is assumed to be 0.37 [126]

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (Av Capacity * 0.473) / 24 * Hours / (L/kWh)

Where:

Av Capacity	= Average capacity (pints per day)
0.473	= Constant to convert Pints to Liters
Hours	= Run hours per year
	= 1620 [127]
L/kWh	= Liters of water per kWh consumed
	= As provided in tables above

Annual kWh calculation results for each capacity class presented below:

[124] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

[125] Based on available data from the Department of Energy's Life Cycle Cost analysis spreadsheet: http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dehumidifier.xls

[126] Assume usage is evenly distributed day vs night, weekend vs weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

[127] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

		Annual kWh		
Capacity Range	Pints/day used	ENERGY STAR	Federal Standard	Savings
≤25	22.4	596	650	54
> 25 to ≤35	30	684	798	114
> 35 to ≤45	40	851	1064	213
> 45 to ≤ 54	49.5	988	1285	297
> 54 to ≤ 75	64.5	1144	1329	185
> 75 to ≤ 185	92.8	1185	1559	374

Summer Coincident Peak Demand Savings

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

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.37 [128]

Summer coincident peak demand calculation results for each capacity class presented below:

		Annual kW		
Capacity Range	Pints/day used	ENERGY STAR	Federal Standard	Savings
≤25	22.4	0.136	0.148	0.012
> 25 to ≤35	30	0.156	0.182	0.027
> 35 to ≤45	40	0.194	0.242	0.048
> 45 to ≤ 54	49.5	0.225	0.293	0.068
> 54 to ≤ 75	64.5	0.261	0.303	0.042
> 75 to ≤ 185	92.8	0.270	0.355	0.085

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

[128] Assume usage is evenly distributed day vs night, weekend vs weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

ENERGY STAR Room Air Conditioner (Time of Sale)

Official Measure Code: Res-Appl-ES RAC-TOS-1

Description

This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR or CEE TIER 1 minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings presented below:

Product Class (BtuH)	Federal Standard (EER)	ENERGY STAR (EER)	CEE TIER 1 (EER)
8,000 to 13,999	>= 9.8	>= 10.8	>= 11.3

Definition of Efficient Equipment

To qualify for this measure the new room air conditioning unit must meet either the ENERGY STAR of CEE TIER 1 efficiency standards presented above.

Definition of Baseline Equipment

The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standards presented above.

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
ENERGY STAR	Indianapolis: 31.4 South Bend: 27.2 Evansville: 42.0 Ft. Wayne: 24.3 Terre Haute: 36.9	0.028	n/a	n/a
CEE TIER 1	Indianapolis: 45.0 South Bend: 39.0 Evansville: 60.3 Ft. Wayne: 34.8 Terre Haute: 53.0	0.041	n/a	n/a

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 9 years[129].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $80 for a CEE TIER 1 unit[130].

[129] Energy Star value for room ACs. www.energystar.gov

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.3[131].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (FLHcool * Btu_H * ((1/EERbase) – (1/EERee)))/1000

Where:

Hours = Full Load Hours of room air conditioning unit
= Varies by location[132]. See table below:

City	FLHcool
Indianapolis	332
South Bend	288
Evansville	445
Ft. Wayne	257
Terre Haute	391

Btu_H = Average size of rebated unit
= 10,000[133]

EER_{base} = Efficiency of baseline unit
= 9.8[134]

EER_{ee} = Efficiency of ENERGY STAR unit
= 10.8[135], or
= Efficiency of CEE Tier 1 unit
= 11.3[136]

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130 Based on field study conducted by Efficiency Vermont

131 Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

132 Based on cooling degree day adjusted values from RLW Report: Final Report Coincidence Factor StudyResidential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

133 Average room AC size from Energy Star website. www.energystar.gov.

134 Minimum Federal Standard for capacity range

135 Minimum qualifying standard for ENERGY STAR

136 Minimum qualifying standard for CEE Tier 1.

For example, a room AC in Indianapolis:

$\Delta kWh_{ENERGY\ STAR}$
$= 332 * 10000 * (1/9.8 – 1/10.8) / 1000$
$= 31.4$ kWh

$\Delta kWh_{CEE\ TIER\ 1}$
$= 332 * 10000 * (1/9.8 – 1/11.3) / 1000$
$= 45.0$ kWh

Summer Coincident Peak Demand Savings

$$\Delta kW = Btu_H * ((1/EER_{base}) – (1/EER_{ee}))/1000 * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.3[137]

$\Delta kW_{ENERGY\ STAR}$
$= 10000 * (1/9.8 – 1/10.8) / 1000 * 0.3$
$= 0.028$ kW

$\Delta kW_{CEE\ TIER\ 1}$
$= 10000 * (1/9.8 – 1/11.3) / 1000 * 0.3$
$= 0.041$ kW

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[137] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

ENERGY STAR Room Air Conditioner Replacement (Low Income, Early Replacement)

Official Measure Code: Res-Appl-ES RAC-LI-1

Description

This measure describes the early removal of an existing inefficient Room Air Conditioner unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. This measure is suitable for a Low Income or a Home Performance program. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment

The efficient condition is a new replacement room air conditioning unit meeting the ENERGY STAR efficiency standard (i.e. with an efficiency rating greater than or equal to 10.8EER).

Definition of Baseline Equipment

The baseline condition is the existing inefficient room air conditioning unit for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard (i.e. with an efficiency rating greater than or equal to 9.8EER).

Deemed Savings for this Measure

	Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Remaining useful life of existing unit (3 years)	Indianapolis: 124 South Bend: 107 Evansville: 166 Ft. Wayne: 95.8 Terre Haute: 146	0.111	n/a	n/a
Remaining Measure Life (next 9 years)	Indianapolis: 31.4 South Bend: 27.2 Evansville: 42.0 Ft. Wayne: 24.3 Terre Haute: 36.9	0.028	n/a	n/a

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 12 Years[138].

[138] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)

The assumed remaining useful life of the existing room air conditioning unit being replaced is 3 years[139].

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) should be calculated as (Actual Cost of ENERGY STAR unit - $50 (incremental cost of ENERGY STAR unit over baseline unit[140]) * 69%[141].

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.3[142].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh for remaining life of existing unit (1st 3 years)

$$= Hours * Btu_H * ((1/EER_{exist}) - (1/EER_{ee}))/1000$$

ΔkWh for remaining measure life (next 9 years)

$$= Hours * Btu_H * ((1/EER_{base}) – (1/EER_{ee}))/1000$$

Where:

Hours = Full Load Hours of room air conditioning unit
= Varies by location[143]. See table below:

[139] Based on Connecticut TRM; Connecticut Energy Efficiency Fund; CL&P and UI Program Savings Documentation for2008 Program Year

[140] From ENERGY STAR calculator (ENERGY STAR - $220, Baseline - $170); http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

[141] 69% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170, divided by the standard efficiency unit cost ($170). The calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost.

[142] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

[143] Based on cooling degree day adjusted values from RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

City	FLHcool
Indianapolis	332
South Bend	288
Evansville	445
Ft. Wayne	257
Terre Haute	391

Btu_H = Average size of rebated unit
= 10,000[144]
EER_{exist} = Efficiency of baseline unit
= 7.7[145]
EER_{base} = Efficiency of baseline unit
= 9.8[146]
EER_{ee} = Efficiency of ENERGY STAR unit
= 10.8[147]

For example, a room AC in Indianapolis:

ΔkWh for remaining life of existing unit (1st 3 years)
$= 332 * 10{,}000 * (1/7.7 – 1/10.8) / 1000$
= 124 kWh

ΔkWh for remaining measure life (next 9 years)
$= 332 * 10{,}000 * (1/9.8 – 1/10.8) / 1000$
= 31.4 kWh

Summer Coincident Peak Demand Savings

ΔkW for remaining life of existing unit (1st 3 years)
$= BtuH * ((1/EER_{exist}) – 1(/EER_{ee})) / 1000 * CF$

ΔkW for remaining measure life (next 9 years)
$= BtuH * ((1/EER_{base}) – (1/EER_{ee})) / 1000 * CF$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.3[148]

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[144] Average room AC size from Energy Star website. www.energystar.gov.
[145] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."
[146] Minimum Federal Standard for capacity range
[147] Minimum qualifying standard for ENERGY STAR
[148] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

ΔkW for remaining life of existing unit (1st 3 years)

$$= 10{,}000 * (1/7.7 - 1/10.8) / 1000 * 0.3$$
$$= 0.11 \text{ kW}$$

ΔkW for remaining measure life (next 9 years)

$$= 10{,}000 * (1/9.8 - 1/10.8) / 1000 * 0.3$$
$$= 0.028 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) should be calculated as (Actual Cost of ENERGY STAR unit - $50 (incremental cost of ENERGY STAR unit over baseline unit[149]) * 69%[150].

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

149 From ENERGY STAR calculator (ENERGY STAR - $220, Baseline - $170); http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

150 69% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170, divided by the standard efficiency unit cost ($170). The calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost.

ENERGY STAR Room Air Conditioner Recycling (Early Retirement)

Official Measure Code: Res-Appl-ES RAC-Recycle-1

Description

This measure describes the savings resulting from running a drop off service taking existing inefficient Room Air Conditioner units from service, prior to their natural end of life. This measure assumes that a percentage of these units will be replaced with a baseline standard efficiency unit (note that if it is actually replaced by a new ENERGY STAR qualifying unit, the savings increment between baseline and ENERGY STAR will be recorded in the Efficient Products program).

Definition of Efficient Equipment

N/A. This measure relates to the retiring of an existing inefficient unit.

Definition of Baseline Equipment

The baseline condition is the existing inefficient room air conditioning unit.

Deemed Savings for this Measure

Average Annual kWh Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Indianapolis: 198 South Bend: 171 Evansville: 265 Ft. Wayne: 153 Terre Haute: 233	0.178	n/a	n/a

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)

The assumed remaining useful life of the existing room air conditioning unit being retired is 3 Years.

Deemed Measure Cost

The actual implementation cost for recycling the existing unit plus the cost for the replacement of some of the units of $129[151].

[151] This is calculated by multiplying the percentage assumed to be replaced – 76% (from Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report") by the assumed cost of a standard efficiency unit of $170 (ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls). 0.76 * 170 =$129.2.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with the replacement of those units that would be replaced, with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) is calculated as $89.36[152].

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.3[153].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = kWh_{exist} - (\%replaced * kWh_{newbase})$$

$$= ((Hours * Btu_H * (1/EER_{exist}))/1000) - (\%_{replaced} * ((Hours * Btu_H * (1/EER_{newbase}))/1000)$$

Where:

Hours = Full Load Hours of room air conditioning unit
= Varies by location[154]. See table below:

City	FLHcool
Indianapolis	332
South Bend	288
Evansville	445
Ft. Wayne	257
Terre Haute	391

Btu_H = Average size of rebated unit
= 10,000[155]

EER_{exist} = Efficiency of baseline unit
= 7.7[156]

[152] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing $170 multiplied by the 76%, the percentage of units being replaced (i.e. 0.76 * $170 = $129.2. Baseline cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

[153] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

[154] Based on cooling degree day adjusted values from RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

[155] Average room AC size from Energy Star website. www.energystar.gov.

$\%_{replaced}$ = Percentage of units dropped off that are replaced
= 76%[157]

EER_{base} = Efficiency of baseline unit
= 9.8[158]

For example, a room AC in Indianapolis:

$\Delta kWh = ((332 * 10{,}000 * (1/7.7)) / 1000) – (0.76 * ((332 * 10{,}000 * (1/9.8)) / 1000)$
$= 197\ kWh$

Summer Coincident Peak Demand Savings

$$\Delta kW = (kW_{exist} – (\%_{replaced} * kW_{newbase})) * CF$$

$$= ((Btu_H * (1/EER_{exist}))/1000) - (\%_{replaced} * ((BtuH * (1/EER_{newbase}))/1000) * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.3[159]

$\Delta kW = ((10{,}000 * (1/7.7)) / 1000) – (0.76 * ((10{,}000 * (1/9.8)) / 1000) * 0.3$
$= 0.178\ kW$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The net present value of the deferred replacement cost (the cost associated with the replacement of those units that would be replaced, with a standard unit that would have had to have occurred in 3 years, had the existing unit not been replaced) is calculated as $89.36[160].

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[156] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."
[157] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report." Report states that 63% were replaced with ENERGY STAR units and 13% with non-ENERGY STAR. However this formula assumes all are non-ENERGY STAR since the increment of savings between baseline units and ENERGY STAR would be recorded by the Efficient Products program when the new unit is purchased.
[158] Minimum Federal Standard for capacity range
[159] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)
[160] Determined by calculating the Net Present Value (with a 5% discount rate) of the annuity payments from years 4 to 12 of a deferred replacement of a standard efficiency unit costing multiplied by the 76%, the percentage of units being replaced (i.e. 0.76 * $170 = $129.2. Baseline cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerRoomAC.xls)

Version Date & Revision History

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Smart Strip Power Strip (Time of Sale)

Official Measure Code: Res-Appl-Strip-1

Description

This measure relates to Controlled Power Strips (or Smart Strips) which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and so are always providing power to any device plugged into it. This measure characterization provides savings for controllable peripheral devices associated with home computers and television sets.

Definition of Efficient Equipment

The efficient case is the use of a smart strip.

Definition of Baseline Equipment

The assumed baseline is a standard power strip that does not control connected loads.

Deemed Savings for this Measure

Average Annual KWH Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
22.6	0.00178	-0.041	n/a

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the smart strip is 4 years[161].

Deemed Measure Cost

The incremental cost of a smart strip over a standard power strip with surge protection is assumed to be $16 for a 5-plug and $26 for a 7-plug[162].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.5

[161] David Rogers, Power Smart Engineering, October 2008; "Smart Strip electrical savings and usability", p22.
[162] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4

REFERENCE SECTION

Calculation of Savings

Energy Savings [163]

$$\Delta kWh = \sum^{Peripherals} W_{standby} \times F_{homes} \times F_{control} \times hr \times (1 + WHF_e) / 1000$$

where:

$W_{standby}$ = power in standby mode
F_{homes} = fraction of homes with peripheral
$F_{control}$ = fraction of peripherals controlled
hr = hours per year peripherals are controlled
= 7474 for computer peripherals
= 6784 for television peripherals
WHF_e = Waste Heat Factor for Energy to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.059. See Appendix B.

Assumptions for home computer related peripherals are shown below:

Peripheral	$W_{standby}$	$F_{control}$	F_{homes}
Flat Panel Monitor	1.29	100.0%	69.3%
CRT Monitor	0.72	100.0%	25.1%
Printer	2.32	80.0%	43.1%
Multifunction Printer w/o fax	7.81	66.7%	4.0%
Multifunction Printer w/ fax	7.57	57.3%	8.3%
Speakers, etc.	4.76	100.0%	0.6%
Scanner	1.42	95.5%	7.4%
Copier	0.32	58.1%	4.8%
Modem	6.46	90.4%	8.1%
Router	5.07	93.3%	9.9%
External Hard Drive	1.13	100.0%	0.3%

Assumptions for television related peripherals are shown below:

Peripheral	$W_{standby}$	$F_{control}$	F_{homes}
DVD Player	2.12	93.3%	53.3%
VCR	5.92	97.9%	21.3%
Stereo	4.07	50.7%	30.9%
Speakers, etc	11.07	86.2%	2.1%
Video Game Console	0.57	98.0%	5.3%
Computer Used for Video	17.77	66.7%	0.3%

[163] Based on: NYSERDA Measure Characterization for Advanced Power Strips

For example:

$$\Delta kWh_{computer} = ((1.29*1.0*0.693) + (0.72*1.0*0.251) + (2.32*0.80*0.431) + (7.81*0.667*0.04) + (7.57*0.573*0.083) + (4.76*1.0*0.006) + (1.42*0.955*0.074) + (0.32*0.581*0.048) + (6.46* 0.904*0.081) + (5.07*0.933*0.099) + (1.13*1.0*0.003)) * 7474 * (1 - 0.059) / 1000$$
$$= 24.8 \text{ kWh}$$

$$\Delta kWh_{television} \quad ((2.12*0.933*0.533) + (5.92*0.979*0.213) + (4.07*0.507*0.309) + (11.07*0.862*0.021) + (0.57*0.98*0.053) + (17.77*0.667*0.003)) * 6784 * (1 – 0.059) / 1000$$
$$= 20.4$$

$$\Delta kWh = (\Delta kWh_{computer} + \Delta kWh_{television}) / 2$$

$$= (24.8 + 20.4) / 2$$
$$= 22.6$$

Summer Coincident Peak Demand Savings

$$\Delta kW = \sum^{Peripherals} W_{standby} \times F_{homes} \times F_{control} \times CF \times (1 + WHF_d) / 1000$$

Where:

WHF_d = Waste Heat Factor for Demand to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.50

Using default data from above:

$$\Delta kW_{computer} = ((1.29*1.0*0.693) + (0.72*1.0*0.251) + (2.32*0.80*0.431) + (7.81*0.667*0.04) + (7.57*0.573*0.083) + (4.76*1.0*0.006) + (1.42*0.955*0.074) + (0.32*0.581*0.048) + (6.46* 0.904*0.081) + (5.07*0.933*0.099) + (1.13*1.0*0.003)) * 0.5 * (1 + 0.057) / 1000$$
$$= 0.00187$$

$$\Delta kW_{television} = ((2.12*0.933*0.533) + (5.92*0.979*0.213) + (4.07*0.507*0.309) + (11.07*0.862*0.021) + (0.57*0.98*0.053) + (17.77*0.667*0.003)) * 0.5* (1 + 0.057) / 1000$$
$$= 0.00169$$

$\Delta kW = (\Delta kW_{computer} + \Delta kW_{television}) / 2$
$= (0.00187 + 0.00169) / 2$
$= 0.00178$

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBTU_{WH} = \Delta kWh * WHF_g$

where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in lighting heat.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient lighting. The weighted average value across all HVAC systems and cities is -0.0018. See Appendix B.

$\Delta MMBTU_{WH} = 22.6 * (- 0.0018)$
$= - 0.041$

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

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Efficient Televisions

Official Measure Code: Res-Appl-TV-1

Description

This section covers efficient flat screen LED and LCD televisions. Rebates for high efficiency televisions are provided to retailers to encourage stocking of high efficiency models (upstream rebates) or consumers to offset the additional costs (downstream rebates).

Definition of Efficient Equipment

Two levels of efficiency are addressed:

1. > 20% less than the maximum allowed "on mode" level in the Version 5.1 Energy Star TV specification for the applicable size of viewing screen area.

2. > 35% less than the maximum allowed "on mode" level in the Version 5.1 Energy Star TV specification for the applicable size of viewing screen area.

Definition of Baseline Equipment

Standard efficiency television meeting Energy Star 4.0 specification

Deemed Calculation for this Measure

See reference section below

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be as shown below:

Efficiency	10-25.4 inches	25.5-35 inches	36-39 inches	40-42 inches	43-49 inches	50+ inches
ES V5.1 +20%	$ 10.00	$ 20.00	$ 30.00	$ 40.00	$ 50.00	$ 60.00
ES V5.1 +35%	$ 10.00	$ 20.00	$ 30.00	$ 40.00	$ 50.00	$ 60.00

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

The summer peak coincidence factor for this measure is 0.37

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (kWhbase – kWhee) * (1+WHF_e)

Where:

kWhbase = annual energy consumption of baseline TV.
kWhee = annual energy consumption of efficient TV
WHFe = Waste Heat Factor for Energy to account for HVAC interactions with efficient appliances. The statewide weighted average is -0.059. See Appendix B.

Baseline and efficient TV annual energy consumption by TV size are shown below[164]:

Unit Energy and Demand for Televisions meeting Energy Star V5.1+20% Specifications

Screen Size	kWhbase	kWhee	Wbase	Wee
10”-25.4”	55.1	39.4	29.3	21
25.5”-35”	125.3	65.2	66.6	34.6
36”-39”	156.9	90.5	83.4	48.1
40”-42”	179.7	109.0	95.5	57.9
43”-49”	209.9	129.6	111.5	68.9
>=50”	259.6	151.5	137.9	80.5

Unit Energy and Demand for Televisions meeting Energy Star V5.1+35% Specifications

Screen Size	kWhbase	kWhee	Wbase	Wee
10”-25.4”	55.1	37.1	29.3	19.7
25.5”-35”	125.3	57.1	66.6	30.4
36”-39”	156.9	74.6	83.4	39.7
40”-42”	179.7	83.7	95.5	44.5
43”-49”	209.9	102.2	111.5	54.3
>=50”	259.6	125.1	137.9	66.5

For example, energy savings for a 36 in TV which is 35% for efficient than Energy Star V5.1:

ΔkWh = (kWhbase – kWhee) * (1+WHF_e)

= (156.9 – 74.6) * (1 – 0.059)
= 77.4 kWh

[164] Deemed savings calculations for efficient televisions taken from workpapers submitted to the California Public Utility Commission by Pacific Gas and Electric Company.

Summer Coincident Peak Demand Savings

$\Delta kW = (Wbase – Wee)/1000 * (1+WHF_d) * CF$

Where:

Wbase = On mode power of baseline TV
Wee = On model power of efficient TV
WHFd = Waste Heat Factor for demand to account for HVAC interactions with efficient televisions. Statewide weighted average is 0.057. See Appendix B.

CF = Summer Peak Coincidence Factor for measure
= 0.37

For example, demand savings for a 36 in TV which is 35% for efficient than Energy Star V5.1:

$\Delta kW = (Wbase – Wee) / 1000 * (1+WHF_d) * CF$
$= (83.4 – 39.7) / 1000 * (1 + 0.057) * .37$
$= 0.017$ kW

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBTU = (kWhbase – kWhee) * WHFg$

Where:

$\Delta MMBTU_{WH}$ = gross customer annual heating MMBTU fuel increased usage for the measure from the reduction in internal heat gain from the TV.

WHF_g = Waste heat factor for fossil fuels to account for HVAC interactions with efficient televisions. Statewide average is -0.0018. See Appendix B.

For example, fossil fuel interactions for a 36 in TV which is 35% for efficient than Energy Star V5.1:

$\Delta MMBtu = (kWhbase – kWhee) * WHFg$
$= (156.9 – 74.6) * (-0.0018)$
$= -0.148$

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Referenced Documents:

Central Air Conditioning (Early Replacement)

Official Measure Code: Res-HVAC-AC-ER-1

Description

This measure describes the early removal of an existing inefficient Central Air Conditioning unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central air conditioning unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER and 12 EER.

Definition of Baseline Equipment

The baseline condition is the existing inefficient central air conditioning unit for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard (i.e. 13 SEER and 11 EER).

Deemed Calculation for this Measure

Annual kWh Savings for remaining life of existing unit (1^{st} 5 years)

$$= (FLH_{cool} * BtuH * (1/SEER_{exist} - 1/SEER_{ee}))/1000$$

Annual kWh Savings for remaining measure life (next 13 years)

$$= (FLH_{cool} * BtuH * (1/13 - 1/SEER_{ee}))/1000$$

Summer Coincident Peak kW Savings for remaining life of existing unit (1^{st} 5 years)

$$= (BtuH * (1/EER_{exist} - 1/EER_{ee}))/1000 * 0.88$$

Summer Coincident Peak kW Savings for remaining measure life (next 13 years)

$$= (BtuH * (1/11 - 1/EER_{ee}))/1000 * 0.88$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years[165].

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)

The assumed remaining useful life of the existing central air conditioning unit being replaced is 5 years166.

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[165] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred after 5 years, had the existing unit not been replaced) should be calculated as (Actual Cost of ENERGY STAR unit - incremental cost of ENERGY STAR unit over baseline unit from table below[167]) * 63%[168].

Efficiency Level	Cost per Ton
SEER 14	$119
SEER 15	$238
SEER 16	$357
SEER 17	$476
SEER 18	$596
SEER 19	$715
SEER 20	$834
SEER 21	$908

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88.

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh for remaining life of existing unit (1st 5 years)
= (FLHcool * BtuH * ((1/SEERexist) – (1/SEERee)))/1000

ΔkWh for remaining measure life (next 13 years)
= (FLHcool * BtuH * ((1/SEERbase) – (1/SEERee)))/1000

Where:

FLH_{cool} = Full load cooling hours

[166] Parameter estimate
[167] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
[168] 63% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 6 to 18 of a deferred replacement of a standard efficiency unit costing $2857, divided by the standard efficiency unit cost ($2857). The calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost. Standard unit cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls

Dependent on location as below:

Location	FLH_{cool} [169]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

BtuH = Size of equipment in BtuH (note 1 ton = 12,000Btuh)
= Actual

$SEER_{exist}$ = SEER Efficiency of existing unit
= Actual[170]

$SEER_{ee}$ = SEER Efficiency of ENERGY STAR unit
= Actual installed

$SEER_{base}$ = SEER Efficiency of baseline unit
= 13[171]

For example, replacing a 3 ton SEER 10 unit with a new SEER 14.5 unit, in Indianapolis:

ΔkWh for remaining life of existing unit (1st 5 years)

$$= (487 * 36000 * (1/10 – 1/14.5)) / 1000$$

$$= 544 \text{ kWh}$$

ΔkWh for remaining measure life (next 13 years)

$$= (487 * 36000 * (1/13 – 1/14.5)) / 1000$$

$$= 139.5 \text{ kWh}$$

Summer Coincident Peak Demand Savings

ΔkW for remaining life of existing unit (1st 5 years)

$$= (BtuH * (1/EER_{exist} - 1/EER_{ee}))/1000 * CF$$

ΔkW for remaining measure life (next 13 years)

$$= (BtuH * (1/EER_{base} - 1/EER_{ee}))/1000 * CF$$

Where:

EER_{exist} = EER Efficiency of existing unit
= Calculate using Actual SEER
= (SEER * 0.9)[172]

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169 Based on prototypical building simulations. See Appendix A.

170 Use actual SEER rating where it is possible to measure or reasonably estimate. When unknown use SEER 10 (DEER estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006)

171 Minimum Federal Standard

EER_{base}	= EER Efficiency of baseline unit
	= 11 [173]
EER_{ee}	= EER Efficiency of ENERGY STAR unit
	= Actual installed
CF	= Summer Peak Coincidence Factor for measure
	= 0.88[174]

For example, replacing a 3 ton SEER 10 unit (EER 9)with a new SEER 14.5, EER 12 unit, in Indianapolis:

ΔkW for remaining life of existing unit (1st 5 years)

$$= (36000 * (1/9 – 1/12)) / 1000 * 0.88$$

$$= 0.88 \text{ kW}$$

ΔkW for remaining measure life (next 13 years)

$$= (36000 * (1/11 – 1/12)) / 1000 * 0.88$$

$$= 0.25 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[172] If SEER is unknown, default EER would be (10 * 0.9) = 9.0. Calculation based on prior assessment of industry equipment efficiency ratings.
[173] Minimum Federal Standard
[174] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com

Central Air Conditioning (Time of Sale)

Official Measure Code: Res-HVAC-AC-1

Description

This measure describes the normal replacement of a central AC unit with a new ENERGY STAR qualifying unit. Savings are calculated between a new baseline unit and an efficient unit.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central air conditioning unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER and 12 EER.

Definition of Baseline Equipment

The baseline condition is a new replacement unit meeting the minimum federal efficiency standard (i.e. 13 SEER and 11 EER).

Deemed Calculation for this Measure

Annual kWh Savings

$$= (FLH_{cool} * BtuH * ((1/13) – (1/SEER_{ee})))/1000$$

Summer Coincident Peak kW Savings

$$= (BtuH * ((1/11) – (1/EER_{ee}))) / 1000 * 0.88$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years[175].

Deemed Measure Cost

The incremental measure cost between a new baseline unit and the efficient unit should be used.

Efficiency Level	Incremental Cost per Ton
SEER 14	$119
SEER 15	$238
SEER 16	$357
SEER 17	$476
SEER 18	$596
SEER 19	$715
SEER 20	$834
SEER 21	$908

[175] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[176].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (FLHcool * BtuH * ((1/SEERbase) – (1/SEERee)))/1000

Where:

FLH_{cool} = Full load cooling hours

Dependent on location as below:

Location	FLH_{cool} [177]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

BtuH = Size of equipment in BtuH (note 1 ton = 12,000Btuh)
= Actual

$SEER_{ee}$ = SEER Efficiency of ENERGY STAR unit
= Actual installed

$SEER_{base}$ = SEER Efficiency of baseline unit
= 13[178]

For example, installing a new SEER 14.5 unit in Indianapolis:

ΔkWh = (487 * 36000 * (1/13 – 1/14.5)) / 1000

= 139.5 kWh

[176] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com.
[177] Based on prototypical building simulations. See Appendix A.
[178] Minimum Federal Standard

Summer Coincident Peak Demand Savings

$\Delta kW = (BtuH * ((1/(EER_{base}) - (1/EER_{ee}))) / 1000 * CF$

Where:

EER_{base} = EER Efficiency of baseline unit
= 11 [179]
EER_{ee} = EER Efficiency of ENERGY STAR unit
= Actual installed
CF = Summer Peak Coincidence Factor for measure
= 0.88

For example, installing a new SEER 14.5, EER 12 unit, in Indianapolis:

$\Delta kW = (36000 * (1/11 - 1/12)) / 1000 * 0.88$

$= 0.25$ kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[179] Minimum Federal Standard

Central Air Source Heat Pump (Early Replacement)

Official Measure Code: Res-HVAC-ASHP-ER-1

Description

This measure describes the early removal of an existing inefficient Central Heat Pump unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central heat pump unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER, 12 EER and 8.2 HSPF.

Definition of Baseline Equipment

The baseline condition is the existing inefficient central heat pump unit for the remaining assumed useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard (i.e. 13 SEER 11 EER and 7.7 HSPF).

Deemed Calculation for this Measure

Annual kWh Savings for remaining life of existing unit (1st 5 years)

$$= (FLH_{cool} * BtuH * (1/SEER_{exist} - 1/SEER_{ee}))/1000 + (FLH_{heat} * BtuH * (1/HSPF_{exist} - 1/HSPF_{ee}))/1000$$

Annual kWh Savings for remaining measure life (next 13 years)

$$= (FLH_{cool} * BtuH * (1/13 - 1/SEER_{ee}))/1000 + (FLH_{heat} * BtuH * (1/7.7 - 1/HSPF_{ee}))/1000$$

Summer Coincident Peak kW Savings for remaining life of existing unit (1st 5 years)

$$= (BtuH * (1/EER_{exist} - 1/EER_{ee}))/1000 * 0.88$$

Summer Coincident Peak kW Savings for remaining measure life (next 13 years)

$$= (BtuH * (1/11 - 1/EER_{ee}))/1000 * 0.88$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years[180].

[180] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed Lifetime of Replaced (Existing) Equipment (for early replacement measures only)

The assumed remaining useful life of the existing central heat pump unit being replaced is 5 years[181].

Deemed Measure Cost

The actual measure cost for removing the existing unit and installing the new should be used.

Deemed O&M Cost Adjustments

The net present value of the deferred replacement cost (the cost associated with the replacement of the existing unit with a standard unit that would have had to have occurred after 5 years, had the existing unit not been replaced) should be calculated as (Actual Cost of ENERGY STAR unit - incremental cost of ENERGY STAR unit over baseline unit from table below[182]) * 63%[183].

Efficiency Level	Cost per Ton
SEER 14	$137
SEER 15	$274
SEER 16	$411
SEER 17	$548
SEER 18	$685

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[184].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh for remaining life of existing unit (1st 5 years)

$$= (FLHcool * BtuH * ((1/SEERexist) – (1/SEERee)))/1000 + (FLH_{heat} * BtuH * ((1/HSPF_{exist}) – (1/HSPF_{ee})))/1000$$

[181] Estimated value from OH TRM.
[182] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).
[183] 63% is the ratio of the Net Present Value (with a 5% discount rate) of the annuity payments from years 6 to 18 of a deferred replacement of a standard efficiency unit costing $2857, divided by the standard efficiency unit cost ($2857). The calculation is done in this way to allow the use of the known ENERGY STAR replacement cost to calculate an appropriate baseline replacement cost. Standard unit cost from ENERGY STAR calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls
[184] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com

ΔkWh for remaining measure life (next 13 years)

$$= (FLHcool * BtuH * ((1/SEERbase) – (1/SEERee)))/1000 + (FLH_{heat} * BtuH * ((1/ HSPF_{base}) – (1/HSPF_{ee})))/1000$$

Where:

FLH_{cool} = Full load cooling hours

Dependent on location as below:

Location	FLH_{cool} [185]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

FLH_{heat} = Full load heating hours

Dependent on location as below:

Location	FLH_{heat} [186]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = Size of equipment in BtuH (note 1 ton = 12,000Btuh)
= Actual

$SEER_{exist}$ = SEER Efficiency of existing unit
= Actual[187]

$SEER_{ee}$ = SEER Efficiency of ENERGY STAR unit
= Actual installed

$SEER_{base}$ = SEER Efficiency of baseline unit
= 13[188]

$HSPF_{exist}$ = Heating Seasonal Performance Factor of existing Air Source Heat Pump
= Actual installed

$HSPF_{ee}$ = Heating Seasonal Performance Factor of efficient Air Source Heat Pump
= Actual installed

$HSPF_{base}$ = Heating Seasonal Performance Factor of baseline Air Source Heat Pump
= 7.7 [189]

[185] Based on prototypical building simulations. See Appendix A.
[186] Heating EFLH extracted from simulations. See Appendix A.
[187] Use actual SEER rating where it is possible to measure or reasonably estimate. When unknown use SEER 10 (DEER estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006)
[188] Minimum Federal Standard
[189] Minimum Federal Standard

For example, replacing a 3 ton SEER 10/HSPF 7.2 unit with a new SEER 14.5/HSPF 8.7 unit, in Indianapolis:

ΔkWh for remaining life of existing unit (1st 5 years)

= (487 * 36000 * (1/10 – 1/14.5)) / 1000 + (1341 * 36000 * (1/7.2 – 1/8.7))

= 1,700 kWh

ΔkWh for remaining measure life (next 13 years)

= (487 * 36000 * (1/13 – 1/14.5)) / 1000 + (1341 * 36000 * (1/7.7 – 1/8.7))

= 860 kWh

Summer Coincident Peak Demand Savings

ΔkW for remaining life of existing unit (1st 5 years)

$= (BtuH * (1/EER_{exist} - 1/EER_{ee}))/1000 * CF$

ΔkW for remaining measure life (next 13 years)

$= (BtuH * (1/EER_{base} - 1/EER_{ee}))/1000 * CF$

Where:

EER_{exist} = EER Efficiency of existing unit
= Calculate using Actual SEER
= (SEER * 0.9)[190]

EER_{base} = EER Efficiency of baseline unit
= 11 [191]

EER_{ee} = EER Efficiency of ENERGY STAR unit
= Actual installed

CF = Summer Peak Coincidence Factor for measure
= 0.88

For example, replacing a 3 ton SEER 10 unit (EER 9)with a new SEER 14.5, EER 12 unit, in Indianapolis:

ΔkW for remaining life of existing unit (1st 5 years)

= (36000 * (1/9 – 1/12)) / 1000 * 0.88

= 0.88 kW

ΔkW for remaining measure life (next 13 years)

= (36000 * (1/11 – 1/12)) / 1000 * 0.88

= 0.25 kW

[190] If SEER is unknown, default EER would be (10 * 0.9) = 9.0. Calculation based on prior assessment of industry equipment efficiency ratings.

[191] Minimum Federal Standard

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Central Air Source Heat Pump (Time of Sale)

Official Measure Code: Res-HVAC-ASHP-1

Description

This measure describes the installation a new ENERGY STAR qualifying unit. Savings are calculated between a new baseline unit and the efficient unit.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a ducted split central heat pump unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER, 12 EER and 8.2 HSPF.

Definition of Baseline Equipment

The baseline condition is a new replacement unit meeting the minimum federal efficiency standard (i.e. 13 SEER 11 EER and 7.7 HSPF).

Deemed Calculation for this Measure

Annual kWh Savings

$$= (FLH_{cool} * BtuH * ((1/13) – (1/SEER_{ee})))/1000 + (FLH_{heat} * BtuH * ((1/7.7) – (1/HSPF_{ee})))/1000$$

Summer Coincident Peak kW Savings

$$= (BtuH * ((1/11) – (1/EER_{ee})))/1000 * 0.88$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years[192].

Deemed Measure Cost

The incremental measure cost of installing the new unit over the baseline unit should be used.

Efficiency Level	Incremental Cost per Ton
SEER 14	$137
SEER 15	$274
SEER 16	$411
SEER 17	$548
SEER 18	$685

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[193].

[192] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (FLHcool * BtuH * ((1/SEERbase) – (1/SEERee)))/1000 + (FLH_{heat} * BtuH * ((1/ $HSPF_{base}$)- (1/$HSPF_{ee}$)))/1000

Where:

FLH_{cool} = Full load cooling hours

Dependent on location as below:

Location	FLH_{cool} [194]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

FLH_{heat} = Full load heating hours

Dependent on location as below:

Location	FLH_{heat} [195]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = Size of equipment in BtuH (note 1 ton = 12,000Btuh)
= Actual

$SEER_{ee}$ = SEER Efficiency of ENERGY STAR unit
= Actual installed

$SEER_{base}$ = SEER Efficiency of baseline unit
= 13[196]

$HSPF_{ee}$ = Heating Seasonal Performance Factor of efficient Air Source Heat Pump
= Actual installed

$HSPF_{base}$ = Heating Seasonal Performance Factor of baseline Air Source Heat Pump
= 7.7 [197]

[193] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com
[194] Based on prototypical building simulations. See Appendix A.
[195] Heating EFLH extracted from simulations. See Appendix A.
[196] Minimum Federal Standard

For example, installing a new SEER 14.5/HSPF 8.7 unit, in Indianapolis:

$$\Delta kWh = (487 * 36000 * (1/13 - 1/14.5)) / 1000 + (1341 * 36000 * (1/7.7 - 1/8.7)) = 860 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = (BtuH * ((1/EER_{base}) - (1/EER_{ee})))/1000 * CF$$

Where:

EER_{base} = EER Efficiency of baseline unit
= 11 [198]
EER_{ee} = EER Efficiency of ENERGY STAR unit
= Actual installed
CF = Summer Peak Coincidence Factor for measure
= 0.5 [199]

For example, installing a new SEER 14.5, EER 12 unit, in Indianapolis:

$$\Delta kW = (36000 * (1/11 - 1/12)) / 1000 * 0.88$$

$$= 0.25 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

197 Minimum Federal Standard
198 Minimum Federal Standard
199 Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

Ground Source Heat Pumps (Time of Sale)

Official Measure Code: Res-HVAC-GSHP-1

Description

This measure relates to the installation of a new Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below. This measure relates to the installation of a new system in an existing home (i.e. time of sale).

Product Type	EER	COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment must be a Ground Source Heat Pump unit meeting the minimum ENERGY STAR efficiency level standards effective at the time of installation as detailed above.

Definition of Baseline Equipment

The baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 13 SEER and 11 EER.

Deemed Calculation for this Measure

Annual kWh Savings = (FLHcool * BtuH * ((1/13) – (1/(EERee * 1.02))/ 1000 + (FLHheat * BtuH * ((1/7.7) – (1/COPee * 3.412))/1000

Summer Coincident Peak kW Savings
= BtuH * ((1/11) – (1/(((EERee * 1.02) * 0.37) + 6.43)))/ 1000 * 0.88

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years [200].

Deemed Measure Cost

The actual installed cost of the Ground Source Heat Pump should be used, minus the assumed installation cost of a 3 ton standard baseline Air Source Heat Pump of $3,609[201].

[200] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[201] Based on DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com). Material cost of 13 SEER AC is $796 per ton, and labor cost of $407 per ton. For a 3 ton unit this would be (796+407) *3 = $3609.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[202].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = (FLH_{cool} * BtuH * ((1/SEER_{base}) - (1/(EER_{ee} * 1.02))/1000 + (FLH_{heat} * BtuH * ((1/HSPF_{base}) - (1/(COP_{ee} * 3.412)))/1000$$

Where:

FLH_{cool} = Full load cooling hours

Dependent on location as below:

Location	FLH_{cool} [203]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

BtuH = Size of equipment in Btuh (note 1 ton = 12,000Btuh)
= Actual installed

$SEER_{base}$ = SEER Efficiency of baseline unit
= 13 [204]

EER_{ee} = EER Efficiency of efficient unit
= Actual installed

1.02 = Constant used to estimate the SEER based on the efficient unit EER[205].

FLH_{heat} = Full load heating hours

202 Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com

203 Based on prototypical building simulations. See Appendix A.

204 Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

205 Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on extrapolation of manufacturer data.

Dependent on location as below:

Location	FLH_{heat} [206]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

$HSPF_{base}$ =Heating Season Performance Factor for baseline unit
=7.7[207]

COP_{ee} = Coefficient of Performance of efficient unit
= Actual Installed

3.413 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF).

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in Indianapolis:

$$\Delta kWH = (FLH_{cool} * BtuH * ((1/SEER_{base}) – (1/(EER_{ee} * 1.02))/1000 + (FLH_{heat} * BtuH * ((1/HSPF_{base}) – (1/COP_{ee} * 3.412))/1000$$

$$\Delta kWH = (487 * 36000 * (1/13 – 1/ (16*1.02))) / 1000 + (1341 * 36000 * (1/7.7 – 1/ (3.5*3.412)) / 1000$$

$$= 2501 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = BtuH * ((1/EER_{base})- (1/(((EER_{ee} * 1.02) * 0.37) + 6.43)))/1000 * CF$$

Where:

EER_{base} = EER Efficiency of baseline unit
= 11 [208]

EER_{ee} = EER Efficiency of ENERGY STAR unit
= Actual installed

1.02 = Constant used to estimate the unit's equivalent air conditioning SEER based on the GSHP unit's EER[209].

This is then converted to the unit's equivalent air conditioning EER to enable comparisons to the baseline unit using the following algorithm:

$$EER_{ac} = (SEER * 0.37) + 6.43$$ [210]

[206] Heating EFLH extracted from simulations. See Appendix A.
[207] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

[208] Minimum Federal Standard; as above.
[209] Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on extrapolation of manufacturer data.

CF = Summer Peak Coincidence Factor for measure
= 0.88

For example, a 3 ton unit with EER rating of 16:

$$\Delta kW = (36000 * (1/11 – 1/ (((16 * 1.02) * 0.37) + 6.43)) / 1000 * 0.88$$

$$= 0.35 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[210] Roberts and Salcido, Architectural Energy Corporation, Feb 2008; “Peak Electric Demand Calculations in the REM/Rate Home Energy Rating Software and REM/Design Home Energy Analysis Software”. This formulaic relationship was derived from 1861 unique combinations of data, from nearly 200,000 ARI-rated residential central air conditioners.

Residential Electronically Commutated (EC) Motors

Official Measure Code: Res-HVAC-ECMotor-1

Description

This section covers the electricity savings associated with electronically commutated (EC) motors used on gas furnace and heat pump supply fans. Energy and demand saving are realized through reductions in fan power due to improved motor efficiency and variable flow operation.

Definition of Efficient Equipment

EC motor applied to furnace or heat pump air handler fan

Definition of Baseline Equipment

Standard furnace or heat pump supply fan motor

Deemed Calculation for this Measure

Annual kWh Savings = 733

Summer Coincident Peak kW Savings = 0

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $250

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

N/A

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = 733 per furnace or air handler

The deemed energy savings per ECM furnace or air handler are taken from an impact evaluation of ECM furnaces in Wisconsin[211]. The study is based on field measurements of furnaces with and without EC motors; and surveys of homeowners and contractors to determine homeowner behavior with respect to fan control strategies for ECM furnaces. The study considers cycling vs. continuous fan operation in furnaces before and after the installation of a furnace with EC motor.

Summer Coincident Peak Demand Savings

$\Delta kW = 0.073\ kW * CF$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.9

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBTU = 0$[212]

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

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Referenced Documents:

[211] See "ECM Furnace Impact Assessment Report," prepared for the Wisconsin Public Service Commission by PA Consulting Group, 2009.
[212] Fossil fuel interactions are expected for this technology, but were not evaluated.

Heat Pump Water Heaters (Time of Sale)

Official Measure Code: Res-DHW-HPWH-1

Description

This measure relates to the installation of a Heat Pump domestic hot water heater in place of a standard electric hot water heater. This is a time of sale measure. Savings are presented dependent on the heating system installed in the home.

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be a Heat Pump domestic hot water heater.

Definition of Baseline Equipment

The baseline condition is assumed to be a standard electric hot water heater.

Deemed Savings for this Measure

Heating System:	Average Annual KWH Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Electric Resistance Heat	499	0.068	n/a	n/a
Heat Pump	1297	0.18	n/a	n/a
Fossil Fuel	2076	0.28	-7.38	n/a

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 10 years[213].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $700 [214].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer coincidence factor is assumed to be 0.346 [215].

[213] Based on ENERGY STAR Residential Water Heaters, Final Criteria Analysis: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAn alysis.pdf

[214] Duke Energy measure cost data, 2012.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = kWh_{base} * ((COP_{new} - COP_{base})/COP_{new}) + kWh_{cooling} - kWh_{heating}$$

Where:

kWh_{base} = Average electric DHW consumption
= 3460 [216]

COP_{new} = Coefficient of Performance (efficiency) of Heat Pump water heater
= 2.0 [217]

COP_{base} = Coefficient of Performance (efficiency) of standard electric water heater
= 0.904 [218]

$kWh_{cooling}$ = Cooling savings from conversion of heat in home to water heat
= 180 [219]

$kWh_{heating}$ = Heating cost from conversion of heat in home to water heat.

Dependent on heating fuel as follows[220]:

$kWh_{heating}$ (electric resistance) = 1,577
$kWh_{heating}$ (heat pump COP 2.0) = 779
$kWh_{heating}$ (fossil fuel) = 0

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215 Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York, adjusted for OH peak definitions. Resultant coincident peak kW is consistent with result shown in FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf

216 Assumption taken from; Residential Water Heaters Technical Support Document for the January 17, 2001, Final Rule Table 9.3.9, p9-34, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/09.pdf Consistent with FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf

217 Efficiency based on ENERGY STAR Residential Water Heaters, Final Criteria Analysis: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAn alysis.pdf

218 As above

219 Determined by calculating the MMBtu removed from the air, applying the REMRate determined percentage (35%) of lighting savings that result in reduced cooling loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar), assuming a SEER 11 central AC unit, multiplying by 64% to adjust for the percentage of IN homes having cooling (East North Central census division from Energy Information Administration, 2005 Residential Energy Consumption Survey; http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc6airconditioningchar/pdf/tablehc12.6.pdf), and applying the Discretionary Usage Adjustment of 0.75 (Based on Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p31)

220 Determined by calculating the MMBtu removed from the air, as above, applying the REMRate determined percentage (45%) of lighting savings that result in increased heating loads, converting to kWh and dividing by efficiency of heating system (1.0 for electric resistance, 2.0 for heat pump).

ΔkWh electric resistance heat	= 3460 * ((2.0 – 0.904) / 2.0) + 180 - 1577 = 499 kWh
ΔkWh heat pump heat	= 3460 * ((2.0 – 0.904) / 2.0) + 180 - 779 = 1,297 kWh
ΔkWh fossil fuel heat	= 3460 * ((2.0 – 0.904) / 2.0) + 180 - 0 = 2,076 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / Hours * CF

Where:

Hours = Full load hours of hot water heater
= 2533 [221]

CF = Summer Peak Coincidence Factor for measure
= 0.346 [222]

ΔkW electric resistance heat	= 499 / 2533 * 0.346 = 0.068 kW
ΔkW heat pump heat	= 1297 / 2533 * 0.346 = 0.18 kW
ΔkW fossil fuel heat	= 2076 / 2533 * 0.346 = 0.28 kW

Fossil Fuel Impact Descriptions and Calculation
(For homes with fossil fuel heating system)

ΔMMBtu = -7.38 MMBtu[223]

[221] Full load hours assumption based on Efficiency Vermont loadshape, calculated from Itron eShapes.
[222] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York, adjusted for OH peak definitions. Resultant coincident peak kW is consistent with result shown in FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf
[223] This is the additional energy consumption (therefore a negative value) required to replace the heat removed from the home during the heating season by the heat pump water heater. Determined by calculating the MMBtu removed from the air, applying the REMRate determined percentage (45%) of lighting savings that result in increased heating loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar), dividing by the efficiency of the heating system (estimated assuming that natural gas central furnace heating is typical for Indiana residences (65% of East North Central census division has a Natural Gas Furnace (based on Energy Information Administration, 2005 Residential Energy Consumption Survey: http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc4spaceheating/pdf/tablehc12.4.pdf))

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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In 2000, 40% of furnaces purchased in Indiana were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process). Assuming typical efficiencies for condensing and non condensing furnace and duct losses, the average heating system efficiency is estimated as follows:
(0.4*0.92) + (0.6*0.8) * (1-0.15) = 0.72.

Low Flow Faucet Aerator (Time of Sale or Early Replacement)

Official Measure Code: Res-DHW-Aerator-1

Description

This measure relates to the installation of a low flow (1.0 - 1.5 GPM) faucet aerator in a home. This could be a retrofit direct install measure or a new installation. Both electric and fossil fuel savings are provided, although only savings corresponding to the hot water heating fuel should be claimed.

Definition of Efficient Equipment

The efficient equipment is a low flow aerator.

Definition of Baseline Equipment

The baseline equipment is a standard faucet aerator using GPM.

Deemed Calculation for this Measure

ΔkWh = ISR * (2.5 - GPMlow) * min/day * 0.57 * (80 - Tmains)
ΔkW = ISR * (2.5 - GPMlow) * min/day * 0.000246 * (80 - Tmains)
ΔMMBTU = ISR * (2.5 - GPMlow) * min/day * 0.00254 * (80 - Tmains)

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 10 years[224].

Deemed Measure Cost

As a retrofit measure, the cost will be the actual cost of the aerator and its installation.
As a measure distributed to, but installed by, participants, the cost will be the cost of the aerator and the distribution costs. As a time of sale measure, the cost is assumed to be $2[225].

Deemed O&M Cost Adjustments

When a retrofit measure, there would be a very small O&M benefit associated with the deferral of the next replacement, but this has conservatively not been characterized.

Coincidence Factor

The coincidence factor for this measure is calculated at 0.0026[226].

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224 DEER assumption for faucet aerators. See www.deeresources.com
225 Navigant Consulting, Ontario Energy Board; "Measures and Assumptions for Demand Side Management (DSM) Planning", April 2009.
226 Calculated as follows: Assume 13% faucet use takes place during peak hours (based on: http://www.aquacraft.com/Download_Reports/DISAGGREGATED-HOT_WATER_USE.pdf)
13% * 3.6 minutes per day (10.9 * 2.56 / 3.5 / 2.2 = 3.6) = 0.47 minutes
= 0.47 / 180 (minutes in peak period) = 0.00262

REFERENCE SECTION

Calculation of Savings

Energy Savings
If electric domestic hot water heater:

ΔkWh = ISR * (GPMbase - GPMlow) * min/day *DR * 8.3 * (Tft - Tmains) * 365 / DHW Recovery Efficiency / 3412

Where:

ISR	= In Service Rate or fraction of units that get installed
Retrofit/Direct Install	= 1.0
Customer self install	= 0.48[227]
GPM_{base}	= Gallons Per Minute of baseline faucet
	= 2.4 [228]
GPM_{low}	= Gallons Per Minute of low flow faucet
	= 1.5 (kitchen), 1.0 (bathroom)
min/day	= Average minutes per day used by each faucet in home
	= 3 (kitchen), 2 (bathroom)
days/y	= Days faucet used per year
	= 365
DR	= Percentage of water flowing down drain (if water is collected in a sink, a faucet aerator will not result in any saved water)
	= 63% [229]
8.3	= Constant to convert gallons to lbs
T_{ft}	= Assumed temperature of water used by faucet
	= 80 [230]
T_{mains}	= Assumed temperature of water entering house

Cold water entering temperatures vary according to climate. Ground water temperature is approximately equal to the annual average temperature, while surface water temperature is approximately equal to the annual average outdoor temperature plus 6°F[231]. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

[227] EGD_2009_DSM_Annual Report from table 27 survey of Install rates: Overall averages of 62% and 34% for kitchen and bath aerators respectively are averaged to get 48%. There is significant variation in rates by building type, aerator type, and distribution so surveying participants is encouraged

[228] In 1998, the Department of Energy adopted a maximum flow rate standard of 2.2 gpm at 60 psi for all faucets: 63 Federal Register 13307; March 18, 1998. Value of 2.4 used to account for a mix of pre and post 1998 units.

[229] Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning" Average of kitchen and bathroom faucets used.

[230] Connecticut Energy Efficiency Fund; CL&P and UI Program Savings Documentation for 2008 Program Year

[231] Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.

City	Groundwater Temperature (°F)	Surface Water Temperature (°F)
Indianapolis	51.9	57.9
South Bend	51.2	57.2
Terre Haute	54.3	60.3
Evansville	56.6	62.6
Ft Wayne	49.5	55.5

DHW Recovery Efficiency
= Recovery efficiency of electric hot water heater
= 0.98 [232]
3412 = Constant to converts Btu to kWh

For example, a 1.5GPM direct installation in Indianapolis:

ΔkWh = 1.0 * (2.4 – 1.5) * 3 * 0.63 * 8.3 * (80 – 57.9) * 365 / 0.98 / 3412
= 34 kWh

Summer Coincident Peak Demand Savings

ΔkW = ISR * (GPMbase - GPMlow) * 60 * DR * 8.3 * (Tft – Tmains) / DHW Recovery Efficiency / 3412 * CF

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.00262

For example, a 1.5GPM direct installation:

ΔkW = 1.0 * (2.4 – 1.5) * 0.63 * 8.3 * (80 – 57.9) * 60 / 0.98 / 3412 * 0.00262

= 0.0059 kW

Fossil Fuel Impact Descriptions and Calculation

If fossil fuel domestic hot water heater, MMBtu savings provided below:

ΔMMBtu = ISR * (GPMbase - GPMlow) * min/day *DR * 8.3 * (Tft - Tmains) * 365 / Gas DHW Recovery Efficiency / 1,000,000

232 Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

Where:

Gas DHW Recovery Efficiency	= Recovery efficiency of gas hot water heater = 0.75 [233]

For example, a 1.5GPM direct installation:

$$\Delta MMBtu = 1.0 * (2.4 - 1.5) * 3 * 0.63 * 8.3 * (80 - 57.9) * 365 / 0.75 / 1{,}000{,}000$$

$$= 0.152 \text{ MMBtu}$$

Water Impact Descriptions and Calculation

Water Savings = ISR * (GPMbase - GPMlow) * min/day *DR

DR = Percentage of water flowing down drain (if water is collected in a sink, a faucet aerator will not result in any saved water)
= 63% [234]

For example, a 1.5GPM direct installation:

Water Savings = ISR * (GPMbase - GPMlow) * min/day * DR * 365
= 1.0 * (2.4 – 1.5) * 3 * 0.63 * 365

= 625 gallons

Deemed O&M Cost Adjustment Calculation

When a retrofit measure, there would be a very small O&M benefit associated with the deferral of the next replacement, but this has conservatively not been characterized.

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[233] Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%.

[234] Estimate consistent with Ontario Energy Board, "Measures and Assumptions for Demand Side Management Planning" Average of kitchen and bathroom faucets used.

Low Flow Showerhead (Time of Sale or Early Replacement)

Official Measure Code: Res-DHW-SH-1

Description

This measure relates to the installation of a low flow showerhead in a home. This is a retrofit direct install measure or a new installation. Both electric and fossil fuel savings are provided, although only savings corresponding to the hot water heating fuel should be claimed.

Definition of Efficient Equipment

The efficient condition is a low flow showerhead.

Definition of Baseline Equipment

The baseline is a standard showerhead using 2.8 GPM.

Deemed Calculation for this Measure

Annual kWh savings

$$\Delta kWh = ISR * (2.8 - GPMlow) * 1.3 * (105 - Tmains)$$

Summer Coincident Peak savings

$$\Delta kW = ISR * (2.8 - GPMlow) * 0.0000666 * (105 - Tmains)$$

Annual MMBTU savings

$$\Delta MMBTU = ISR * (2.8 - GPMlow) * 0.0058 * (105 - Tmains)$$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 5 years [235].

Deemed Measure Cost

As a retrofit measure, the incremental cost will be the cost of the showerhead including its installation. As a measure distributed to, but installed by, participants, the cost will be the cost of the showerhead and the distribution costs. As a time of sale measure, the incremental cost is assumed to be $6[236].

[235] Conservative estimate based on review of TRM assumptions from other States.
[236] Navigant Consulting, Ontario Energy Board, "Measures and Assumptions for Demand Side Management (DSM) Planning", April 2009.

Deemed O&M Cost Adjustments

When a retrofit measure, there would be a very small O&M benefit associated with the deferral of the next replacement, but this has conservatively not been characterized.

Coincidence Factor

The coincidence factor for this measure is calculated at 0.00371[237].

REFERENCE SECTION

Calculation of Savings

Energy Savings
If electric domestic hot water heater:

ΔkWh = ISR * (GPMbase - GPMlow) * min/day * # people * shower/per * 8.3 * (Tshower - Tmains) * 365 / DHW Recovery Efficiency / 3412

Where:

ISR = In Service Rate or fraction of units that get installed

Retrofit/Direct Install = 1.0
Customer self install = 0.81[240]

GPMbase = Gallons Per Minute of baseline showerhead
= 2.8
GPMlow = Gallons Per Minute of low flow showerhead
= Actual
people = Average number of people per household
= 2.46 [238]
shower/per = Average showers/per - day
= 0.58
days/y = Days shower used per year
= 365
min/day = Average minutes per shower
= 8.36
8.3 = Constant to convert gallons to lbs
Tshower = Assumed temperature of water used for shower
= 105

[237] Calculated as follows: Assume 9% showers take place during peak hours (based on: http://www.aquacraft.com/Download_Reports/DISAGGREGATED-HOT_WATER_USE.pdf)
9% * 7.42 minutes per day (11.6 * 2.56 / 1.6 / 2.5 = 7.42) = 0.668 minutes
= 0.668 / 180 (minutes in peak period) = 0.00371

[238] US Energy Information Administration, Residential Energy Consumption Survey, East North Central Census Division;
http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/hc3demographics/pdf/tablehc12.3.pdf

Tmains = Assumed temperature of water entering house
RE_{elec} = Recovery efficiency of electric hot water heater
= 0.98 [234]

Cold water entering temperatures vary according to climate. Ground water temperature is approximately equal to the annual average outdoor temperature plus 6°F[239]. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Groundwater Temperature (°F)	Surface Water Temperature (°F)
Indianapolis	51.9	57.9
South Bend	51.2	57.2
Terre Haute	54.3	60.3
Evansville	56.6	62.6
Ft Wayne	49.5	55.5

For example, a 2.0 GPM direct installation in Indianapolis:

$$\Delta kWh = 1.0 * (2.8 - 2.0) * 8.36 * 2.46 * 0.58 * 8.3 * (80 - 57.9) * 365 / 0.98 / 3412$$
$$= 407$$

Summer Coincident Peak Demand Savings
If electric domestic hot water heater:

$$\Delta kW = ISR * (GPMbase - GPMlow) * 60 * 8.3 * (Tshower - Tmains) / DHW\ Recovery\ Efficiency / 3412 * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.00371 [240]

For example, a 2.0 GPM direct installation in Indianapolis:

$$\Delta kW = 1.0 * (2.8 - 2.0) * 60 * 8.3 * (80 - 57.9) * 365 / 0.98 / 3412 * 0.00371$$

$$= 0.021\ kW$$

Fossil Fuel Impact Descriptions and Calculation
If fossil fuel domestic hot water heater:

[239] Water mains temperatures estimated from annual average temperature taken from: Burch, Jay and Craig Christensen; "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory.
[240] Calculated as follows: Assume 9% showers take place during peak hours (based on: http://www.aquacraft.com/Download_Reports/DISAGGREGATED-HOT_WATER_USE.pdf)
9% * 7.42 minutes per day (11.6 * 2.56 / 1.6 / 2.5 = 7.42) = 0.668 minutes
= 0.668 / 180 (minutes in peak period) = 0.00371

ΔMMBtu = ISR * (GPMbase - GPMlow) * min/day * # people * shower/per * 8.3 * (Tshower - Tmains) * 365 / DHW Recovery Efficiency / 1,000,000

Where:

RE_{gas} = Recovery efficiency of gas hot water heater
= 0.75

For example, a 2.0 GPM direct installation in Indianapolis:

ΔMMBtu = 1.0 * (2.8 – 2.0) * 8.36 * 2.46 * 0.58 * 8.3 * (80 – 57.9) * 365 / 0.75 / 1,000,000
= 1.82

Water Impact Descriptions and Calculation

Water Savings = ISR * (GPMbase - GPMlow) * min/day * # people * shower/per * 365

For example, a 2.0 GPM direct installation:

Water Savings =1.0 * (2.8 – 2.0) * 8.36 * 2.46 * 0.58 * 365

= 3483 gallons

Deemed O&M Cost Adjustment Calculation

When a retrofit measure, there would be a very small O&M benefit associated with the deferral of the next replacement, but this has conservatively not been characterized.

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Domestic Hot Water Pipe Insulation (Retrofit)

Official Measure Code: Res-DHW-PipeIns-1

Description

This measure describes adding insulation to un-insulated domestic hot water pipes. The measure assumes the pipe wrap is installed to the first length of both the hot and cold pipe up to the first elbow.

Definition of Efficient Equipment

To efficiency case is installing pipe wrap insulation to a length of hot water carrying copper pipe.

Definition of Baseline Equipment

The baseline is an un-insulated hot water carrying copper pipe.

Deemed Calculation for this Measure

Annual kWh savings (electric DHW systems)

$$= ((1 – 1/Rnew) * (L * C) * 170.2$$

Summer Coincident Peak Savings (electric DHW systems)

$$= \Delta kWh/8760$$

Annual MMBtu savings (fossil fuel DHW systems)

$$= ((1 – 1/Rnew) * (L * C) * 0.569$$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 15 years[241].

Deemed Measure Cost

The measure cost including material and installation is assumed to be $3 per linear foot[242].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

This measure assumes a flat loadshape and as such the coincidence factor is 1.

[241] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[242] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

REFERENCE SECTION

Calculation of Savings

Energy Savings
For electric DHW systems:

ΔkWh = $((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8{,}760) / \eta DHW / 3412$

Where:

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) (Btu/hr-°F-ft)
= 1.0[243]
R_{new} = Pipe heat loss coefficient of insulated pipe (new) (Btu/hr-°F-ft)
= Actual
L = Length of pipe from water heating source covered by pipe wrap (ft)
= actual
C = Circumference of pipe (ft) (Diameter (in) * π * 0.083)
= actual (0.5" pipe = 0.13ft, 0.75" pipe = 0.196ft)
ΔT = Average temperature difference between supplied water and outside air temperature (°F)
= 65°F [244]
8,760 = Hours per year
ηDHW = Recovery efficiency of electric hot water heater
= 0.98 [245]
3412 = Conversion from Btu to kWh

For example, insulating 5 feet of 0.75" pipe with R-4 wrap:

ΔkWh = $((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8{,}760) / \eta DHW / 3413$

= ((1/1– 1/5) * (5 * 0.196) * 65 * 8760) / 0.98 /3413

= 133 kWh

Summer Coincident Peak Demand Savings

ΔkW = $\Delta kWh/8760$

Where:

ΔkWh = kWh savings from pipe wrap installation

[243] Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", p77.
[244] Assumes 130°F water leaving the hot water tank and average temperature of basement of 65°F.
[245] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

8760 = Number of hours in a year (since savings are assumed to be constant over year).

For example, insulating 5 feet of 0.75" pipe with R-4 wrap:

$\Delta kW = 133/8760$

$= 0.015kW$

Fossil Fuel Impact Descriptions and Calculation
For fossil fuel DHW systems:

$$\Delta MMBtu = ((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8{,}760) / \eta DHW / 1{,}000{,}000$$

Where:

ηDHW = Recovery efficiency of gas hot water heater
= 0.75 [246]

For example, insulating 5 feet of 0.75" pipe with R-4 wrap:

$$\Delta MMBtu = ((1/1 - 1/5) * (5 * 0.196) * 65 * 8760) / 0.75 / 1{,}000{,}000$$

$$= 0.60\ MMBtu$$

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[246] Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%.

Wall Insulation (Retrofit)

Official Measure Code: Res-Shell-WallIns-1

Description

This measure characterization is for the installation of new additional insulation in the walls of a residential building. The measure assumes that an auditor, contractor or utility staff member is on location, and will measure and record the existing and new insulation thickness and type (to calculate R-values), and the surface area of insulation added.

Definition of Efficient Equipment

The new insulation should meet any qualification criteria required for participation in the program. The new insulation R-value should include any existing insulation that is left in situ and the appropriate adjustment factors for insulation compression and void fraction.

Definition of Baseline Equipment

The existing insulation R-value should include appropriate adjustment factors for insulation compression and void fraction. The R-value should include the insulation layer only; air gaps and other building materials are accounted for in the simulation models.

Deemed Calculation for this Measure

Annual kWh savings

$$\Delta kWh = kSF \times \Delta kWh/kSF$$

Summer Coincident Peak kW Savings

$$\Delta kW_S = kSF \times \Delta kW/kSF \times CF_S$$

Fossil Fuel Savings

$$\Delta MMBTU = kSF \times \Delta MMBTU/kSF$$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 25 years [247].

Deemed Measure Cost

The actual insulation installation measure cost should be used.

[247] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[248].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = kSF \times \Delta kWh/kSF$$

Where:

kSF = area of installed insulation (1000 sq. ft.)
= actual recorded
ΔkWh/kSF = unit energy savings from lookup table

Unit energy savings values are provided for a set of baseline and measure R-values; and HVAC system types. Values are provided for homes with and without cooling, and for homes with gas, heat pump, or electric resistance heating systems. The R-values are for the insulation layer only; R-values of building materials and air gaps are included in the simulation model. Interpolation within the tables is permissible for R-values not explicitly listed. The baseline and measure R-values should consider installation conditions such as insulation compression and coverage. Insulation compression adjustment factors (Fcomp) are shown below:

% Compression	Fcomp
0%	1.00
5%	0.97
10%	0.93
15%	0.89
20%	0.85

An additional adjustment should be taken for the insulation coverage. This factor (Fvoid) is determined by the installation grade or void fraction; and the ratio of the insulation R-value to the full assembly R-value. The insulation coverage adjustment is shown below:

[248] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com

RmfgxFcomp / Rtotal	Fvoid	
	2% Void (Grade II)	5% Void (Grade III)
0.50	0.96	0.90
0.55	0.96	0.90
0.60	0.95	0.88
0.65	0.94	0.87
0.70	0.94	0.85
0.75	0.92	0.83
0.80	0.91	0.79
0.85	0.88	0.74
0.90	0.83	0.66
0.95	0.71	0.49
0.99	0.33	0.16

The adjusted R-value is the nominal R-value times the adjustment factors:

Radj = Rnominal x Fcomp x Fvoid

For example, 300 square feet of wall insulation is installed in an average Indianapolis home. The home started with an uninsulated 2x4 wall and was insulated to R-13 with no compression or void fraction.

ΔkWh = kSF x ΔkWh/kSF

= 0.3 x 552
= 166 kWh

Summer Coincident Peak Demand Savings

ΔkW_S = kSF x ΔkW/kSF x CF

Where:

ΔkW/kSF = unit demand savings from lookup table
CF = Summer Peak Coincidence Factor for measure
= 0.88

Using the values from the example above and looking up the kW/kSF value from the Table below:

ΔkW_S = kSF x ΔkW/kSF x CF

= 0.3 x 0.0787 x 0.88
= 0.021 kW

Space Heating Savings Calculation

ΔMMBTU = kSF x ΔMMBTU/kSF

Where:

ΔMMBTU/kSF = unit fossil fuel energy savings from lookup table

Using the values from the example above and looking up the kW/kSF value from the Table below:

ΔMMBTU = kSF x ΔMMBTU/kSF
= 0.3 x 7.07
= 2.1

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Building: Single Family **City: Indianapolis** **HVAC: Weighted Average** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	483.4	0.0747	6.16												
13	552.1	0.0787	7.07	68.7	0.0040	0.91									
17	659.7	0.0981	8.45	176.3	0.0234	2.28	107.6	0.0193	1.37						
19	699.0	0.0988	8.98	215.6	0.0242	2.81	146.9	0.0200	1.90	39.3	0.0007	0.53			
21	731.1	0.1134	9.42	247.7	0.0387	3.27	179.1	0.0348	2.36	71.5	0.0153	0.91	32.1	0.0146	0.46
25	783.4	0.1141	10.05	300.0	0.0395	3.89	231.3	0.0355	2.98	123.7	0.0160	1.60	84.4	0.0153	1.08
27	803.8	0.1181	10.35	320.4	0.0434	4.18	251.7	0.0395	3.27	144.1	0.0200	1.90	104.9	0.0193	1.37

Building: Single Family **City: South Bend** **HVAC: Weighted Average** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	478.9	0.0500	6.23												
13	552.8	0.0507	7.22	74.0	0.0007	0.99									
17	661.0	0.0660	8.60	182.2	0.0160	2.37	108.2	0.0153	1.38						
19	699.1	0.0660	9.13	220.3	0.0160	2.89	146.3	0.0153	1.90	38.1	0.0000	0.53			
21	730.2	0.0660	9.51	251.4	0.0160	3.34	177.4	0.0153	2.36	69.2	0.0000	0.91	31.0	0.0000	0.46
25	782.4	0.0693	10.20	303.5	0.0193	4.03	229.6	0.0185	2.98	121.4	0.0032	1.60	83.3	0.0032	1.08
27	803.3	0.0700	10.50	324.4	0.0200	4.27	250.5	0.0193	3.27	142.3	0.0040	1.90	104.1	0.0040	1.37

Building: Single Family **City: Evansville** **HVAC: Weighted Average** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	391.6	0.0934	5.00												
13	455.5	0.1087	5.78	63.8	0.0153	0.84									
17	548.6	0.1367	6.92	156.9	0.0433	1.98	93.1	0.0274	1.14						
19	580.3	0.1408	7.37	188.7	0.0475	2.36	124.9	0.0314	1.60	31.7	0.0040	0.38			
21	607.2	0.1522	7.68	215.6	0.0588	2.74	151.8	0.0433	1.90	58.6	0.0153	0.76	27.0	0.0113	0.38
25	649.2	0.1561	8.27	257.5	0.0628	3.27	193.7	0.0475	2.43	100.6	0.0193	1.29	68.9	0.0153	0.91
27	666.7	0.1675	8.44	275.0	0.0741	3.50	211.2	0.0588	2.66	118.1	0.0306	1.52	86.4	0.0266	1.14

Building: Single Family **City: Ft Wayne** **HVAC: Weighted Average** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	309.7	0.0276	4.03												
13	357.9	0.0357	4.64	48.2	0.0089	0.61									
17	425.6	0.0451	5.55	115.9	0.0183	1.52	67.7	0.0094	0.91						
19	450.4	0.0451	5.93	140.6	0.0183	1.82	92.4	0.0094	1.22	24.8	0.0000	0.30			
21	470.8	0.0451	6.16	161.1	0.0183	2.13	112.9	0.0094	1.52	45.3	0.0000	0.61	20.4	0.0000	0.30
25	504.2	0.0451	6.61	194.5	0.0183	2.58	146.4	0.0094	1.90	78.6	0.0000	1.06	53.9	0.0000	0.68
27	516.8	0.0455	6.76	207.1	0.0187	2.74	158.9	0.0098	2.13	91.3	0.0004	1.22	66.5	0.0004	0.85

Building: Single Family **City: Terre Haute** **HVAC: Weighted Average** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	299.4	0.0281	3.88												
13	347.1	0.0281	4.56	47.7	0.0000	0.61									
17	417.7	0.0366	5.40	118.3	0.0094	1.52	70.6	0.0094	0.91						
19	440.7	0.0366	5.71	141.3	0.0094	1.82	93.6	0.0094	1.22	23.0	0.0000	0.30			
21	461.9	0.0366	6.00	162.5	0.0094	2.13	114.8	0.0094	1.46	44.3	0.0000	0.61	21.3	0.0000	0.30
25	493.8	0.0459	6.46	194.4	0.0187	2.51	146.7	0.0187	1.90	76.1	0.0094	0.99	53.1	0.0094	0.68
27	507.8	0.0459	6.61	208.4	0.0187	2.66	160.7	0.0187	2.05	90.1	0.0094	1.20	67.1	0.0094	0.84

Air Sealing - Reduce Infiltration (Retrofit)

Official Measure Code: Res-Shell-AirSeal-1

Description

This measure characterization is for the improvement of a building's air-barrier, which together with its insulation defines the thermal boundary of the conditioned space. Air-leakage in buildings represents from 5% to 40% of the space conditioning costs[249] but is also very difficult to control. The measure assumes that a trained auditor, contractor or utility staff member is on location, and will measure and record the existing air- leakage rate[250] and post air-sealing leakage using a blower door.

Definition of Efficient Equipment

Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. The initial and final tested leakage rates should be performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

Definition of Baseline Equipment

The existing air leakage should be determined through approved and appropriate test methods. The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing.

Deemed Calculation for this Measure

$\Delta kWh = ((CFM50Exist – CFM50New) / N\text{-}factor) \times \Delta kWh/CFM$

$\Delta kW = ((CFM50Exist – CFM50New) / N\text{-}factor) \times \Delta kW/CFM \times CF$

$\Delta MMBTU = ((CFM50Exist – CFM50New) / N\text{-}factor) * \Delta MMBTU/ CFM$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 15 years[251].

Deemed Measure Cost

The actual air sealing measure cost should be used.

Deemed O&M Cost Adjustments

n/a

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249 Krigger, J. Dorsi, C. "Residential Energy" 2004, p.73
250 In accordance with industry best practices see: BPI Building Analyst and Envelope Professional standards, http://www.bpi.org/standards_approved.aspx
251 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[252].

REFERENCE SECTION

Calculation of Savings

kWh Savings

ΔkWh = ((CFM50Exist – CFM50New) / N-factor) x ΔkWh/CFM

Where:

$CFM50_{Exist}$ = Existing Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door before airsealing.
= actual recorded

$CFM50_{New}$ = New Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door after airsealing.
= actual recorded

N-Factor = Conversion factor to convert 50-pascal air flows to natural airflow.
= dependent on exposure level[253]:

Exposure	Cooling	Heating
Well Shielded	24	18
Normal	20	15
Exposed	18	13

ΔkWh/CFM = kWh impacts per CFM of infiltration rate reduction

Electricity impacts per CFM of leakage reductions are provided for homes with and without cooling, and for homes with gas, heat pump, or electric resistance heating systems. See reference tables at the end of this section.

For example, reducing air leakage in a well-shielded Indianapolis home from 5000 CFM50 to 3500 CFM50, with central AC and gas heat:

ΔkWh = ((5000 – 3500) / 24) x 2.1
= 177kWh

[252] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com
[253] Krigger, J and C. Dorsi. "Residential Energy" 2004 p. 284.

Summer Coincident Peak Demand Savings

ΔkW = ((CFM50Exist – CFM50New) / N-factor) x ΔkW/CFM x CF

Where:

ΔkW/CFM = kW impacts per CFM of infiltration rate reduction

CF = Summer Peak Coincidence Factor for measure
= 0.88

For example, reducing air leakage in a well-shielded Indianapolis home from 5000 CFM50 to 3500 CFM50, with central AC and gas heat:

ΔkW = ((5000 – 3500) / 24) x .001 x 0.88
= 0.074

Fossil Fuels Savings Calculation

ΔMMBTU = ((CFM50Exist – CFM50New) / N-factor) * ΔMMBTU/ CFM

Where:

ΔMMBTU/CFM = fossil fuel impacts per CFM of infiltration rate reduction

ΔMMBTU = ((5000 – 3500) / 18) x 0.21
= 18 MMBtu

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Electricity and Fossil Fuel Impacts of Air Leakage Sealing[254]

City	AC Gas Heat			Heat Pump		AC Electric Heat		Gas Heat Only			Electric Heat Only	
	kWh/cfm	kW/cfm	MMBtu/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	kWh/cfm	kW/cfm	MMBtu/cfm	kWh/cfm	kW/cfm
Indianapolis	2.1	0.001	0.21	30.6	0.003	49.8	0.006	1.1	0.000	0.22	48.2	0.000
South Bend	1.5	0.001	0.20	29.8	0.003	47.4	0.003	1.0	0.000	0.21	46.5	0.000
Evansville	2.6	0.004	0.16	20.1	0.006	39.9	0.008	0.8	0.000	0.17	36.9	0.000
Ft Wayne	1.8	0.001	0.24	35.7	0.002	53.8	0.001	1.2	0.000	0.24	53.1	0.000
Terre Haute	2.6	0.000	0.19	24.4	0.003	43.1	0.000	0.9	0.000	0.19	41.4	0.000

City	Weighted Average		
	kWh/cfm	kW/cfm	MMBtu/cfm
Indianapolis	12.62	0.0018	0.1609
South Bend	11.73	0.0013	0.1533
Evansville	10.47	0.0042	0.1229
Ft Wayne	13.46	0.0009	0.1824
Terre Haute	11.32	0.0001	0.1444

[254] Infiltration unit savings derived from residential simulation models. See Appendix F.

Duct Sealing and Insulation (Retrofit)

Official Measure Code: Res-HVAC-DTS-1

Description

This measure describes evaluating the savings associated with performing duct sealing and insulation upgrades. Duct sealing is done using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system. The methodology requires either a measurement of duct leakage amount and observation of duct insulation R-value; or evaluation of three duct characteristics below and use of the Building Performance Institutes 'Distribution Efficiency Look-Up Table':

a. Percentage of duct work found within the conditioned space
b. Duct leakage evaluation
c. Duct insulation evaluation

Definition of Efficient Equipment

The efficient condition is sealed and/or insulated duct work throughout the unconditioned space in the home.

Definition of Baseline Equipment

The existing baseline condition is leaky and/or uninsulated duct work within the unconditioned space in the home.

Deemed Calculation for this Measure

Annual kWh savings

Cooling savings for homes with central air conditioning:

$$\Delta kWh = (DE_{after} - DE_{before}) / DE_{after} * FLH_{cool} * BtuH / SEER / 1000$$

Heating savings for homes with electric heat (Heat Pump of resistance):

$$\Delta kWh = (DE_{after} - DE_{before}) / DE_{after} * FLHheat * BtuH / \eta Heat / 3412$$

Summer Coincident Peak kW savings

$$\Delta kW = (DE_{pk,after} - DE_{pk,before}) / DE_{pk,after} * BtuH / EER / 1000 * CF$$

Annual Fossil Fuel Savings Algorithm

$$\Delta MMBTUfossil\ fuel = (DE_{after} - DE_{before}) / DE_{after} * FLHheat * BtuH / 1,000,000 / \eta Heat$$

Deemed Lifetime of Efficient Equipment

The assumed lifetime of this measure is 20 years[255].

Deemed Measure Cost

The actual duct sealing and insulation measure cost should be used.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[256]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh_{cooling} = (DE_{after} - DE_{before}) / DE_{after} * FLH_{cool} * BtuH / SEER / 1000$$

Where:

DE_{after} = Distribution Efficiency after duct sealing
DE_{before} = Distribution Efficiency before duct sealing
FLH_{cool} = Full Load Cooling Hours
= Dependent on location as below:

Location	FLH_{cool} [257]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

BtuH = Size of equipment in Btuh (note 1 ton = 12,000Btuh)
= Actual
SEER = Seasonal average efficiency in SEER of Air Conditioning equipment
= actual. If not available use:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

255 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
256 Duke Energy data for residential AC loads
257 Based on prototypical building simulations. See Appendix A.

Determine Distribution Efficiency from the distribution efficiency lookup table at the end of this section using pre and post duct leakage measurements and insulation R-values; or by evaluating duct system before and after duct sealing and insulation using Building Performance Institute "Distribution Efficiency Look-Up Table[258]"

For example, duct sealing in a house in Indianapolis, with 3-ton SEER 11 central air conditioning and the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

$\Delta kWh = ((0.92 - 0.85)/0.92) * 487 * 36000 / 11 / 1000$

$= 121\ kWh$

<u>Heating savings for homes with electric heat (heat pump or resistance):</u>

$kWh = (DE_{after} - DE_{before}) / DE_{after} * FLHheat * BtuH \ / \ / \ \eta Heat \ / \ 3412$

Where:

FLHheat = Full Load Heating Hours
= Dependent on location as below:

Location	FLH_{heat}[259]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = Size of equipment in Btuh
= Actual

ηHeat = Efficiency in COP of Heating equipment
= actual. If not available use:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	n/a	n/a	1.00

258 http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf
259 Heating EFLH extracted from simulations. See Appendix A.

For example, duct sealing in a house in Indianapolis, with a 100,000 Btu/hr 6.8 HSPF heat pump and the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

$$\Delta kWh = (0.92 - 0.85)/0.92 * 1341 * 100000 / 2 / 3412$$

$$= 1495 \text{ kWh}$$

Summer Coincident Peak kW savings

$$\Delta kW = (DE_{pk,after} - DE_{pk,before}) / DE_{pk,after} * BtuH / EER / 1000 * CF$$

Where:

$DE_{pk,after}$ = Distribution Efficiency under peak summer conditions after duct sealing

$DE_{pk,before}$ = Distribution Efficiency under peak summer conditions before duct sealing

CF = Summer Peak Coincidence Factor for measure
= 0.88

EER = Peak efficiency in EER of Air Conditioning equipment
= actual. If EER is unknown, calculate based on SEER[260]:
= $(-0.02 * SEER^2) + (1.12 * SEER)$

Annual Fossil Fuel Savings Algorithm

<u>For homes with Fossil Fuel Heating:</u>

$$\Delta MMBTUfossil\ fuel = (DE_{after} - DE_{before}) / DE_{after} * FLHheat * BtuH / 1{,}000{,}000 / \eta Heat$$

Where:

DE_{after} = Distribution Efficiency after duct sealing

DE_{before} = Distribution Efficiency before duct sealing

FLHheat = Full Load Heating Hours

[260] Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Master's Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

Dependent on location as below:

Location	FLH_{heat} [261]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = Capacity of Heating System
= Actual

ηHeat = Efficiency of Heating equipment
= Actual. If not available use 84%[262].

For example, duct sealing in a house in Indianapolis with a 100,000 Btu/hr 84 AFUE gas furnace with the following duct evaluation results:

DE_{after} = 0.92
DE_{before} = 0.85

Energy Savings:

$$\Delta MMBTU = ((0.92 - 0.85)/0.92) * 1341 * 100,000 / 1,000,000 / 0.84$$

$$= 12.1 \text{ MMBtu}$$

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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261 Heating EFLH extracted from simulations. See Appendix A.
262 The System Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing. If there is more than one heating system, the weighted (by consumption) average efficiency should be used.
If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.

Reference Tables

Distribution efficiencies based on observed R-values and measured leakage rates are shown below[263].

Single Family Distribution System Efficiency, Ducts Located in Unconditioned Basement

Duct total leakage (%)	Duct system R-value (supply and return)	Cooling		Heating
		DE_{cool}	DE_{pk}	DE_{heat}
8%	Uninsulated	0.88	0.86	0.74
10%	Uninsulated	0.87	0.84	0.73
15%	Uninsulated	0.84	0.82	0.71
20%	Uninsulated	0.82	0.79	0.68
25%	Uninsulated	0.80	0.76	0.66
30%	Uninsulated	0.77	0.73	0.64
8%	R-4.2	0.91	0.90	0.88
10%	R-4.2	0.90	0.89	0.87
15%	R-4.2	0.88	0.86	0.84
20%	R-4.2	0.86	0.83	0.82
25%	R-4.2	0.83	0.80	0.79
30%	R-4.2	0.81	0.78	0.77
8%	R-8	0.92	0.91	0.90
10%	R-8	0.91	0.89	0.89
15%	R-8	0.88	0.86	0.86
20%	R-8	0.86	0.84	0.83
25%	R-8	0.84	0.81	0.81
30%	R-8	0.81	0.78	0.78

[263] Distribution efficiencies calculated according to ASHRAE Standard 152-2004, “Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems” using Indianapolis climate data.

Single Family Distribution System Efficiency, Ducts Located in Unconditioned Attic[264]

Duct total leakage (%)	Duct system R-value (supply and return)	Cooling		Heating
		DE_{cool}	DE_{pk}	DE_{heat}
8%	Uninsulated	0.68	0.54	0.69
10%	Uninsulated	0.66	0.52	0.68
15%	Uninsulated	0.62	0.47	0.65
20%	Uninsulated	0.58	0.42	0.63
25%	Uninsulated	0.55	0.37	0.60
30%	Uninsulated	0.51	0.32	0.58
8%	R-4.2	0.84	0.79	0.86
10%	R-4.2	0.83	0.77	0.85
15%	R-4.2	0.78	0.71	0.82
20%	R-4.2	0.74	0.65	0.79
25%	R-4.2	0.70	0.59	0.76
30%	R-4.2	0.66	0.54	0.73
8%	R-8	0.86	0.82	0.88
10%	R-8	0.84	0.79	0.87
15%	R-8	0.80	0.73	0.84
20%	R-8	0.76	0.67	0.81
25%	R-8	0.71	0.62	0.78
30%	R-8	0.67	0.56	0.75

264 Ibid

ENERGY STAR Windows (Time of Sale)

Official Measure Code: Res-Shell-ESWind-1

Description

This measure describes the purchase of ENERGY STAR Windows meeting the minimum requirement for the North Central region (Evansville) or Northern region (Indianapolis, South Bend, Ft. Wayne, Terre Haute) at natural time of replacement or new construction. This does not relate to a window retrofit program.

Definition of Efficient Equipment

To qualify for this measure, the new window must meet ENERGY STAR criteria for the North Central region (u factor ≤ 0.32; SHGC ≤ 0.40) or Northern region (u factor ≤ 0.30). There is no minimum criterion for Solar Heat Gain Coefficient (SHGC) for windows in the North region, so a medium gain window with SHGC of 0.40 is assumed.

Definition of Baseline Equipment

The baseline window is assumed to be a code-compliant window in IECC Climate Zone 4 (u factor = 0.35, SHGC = 0.40) or IECC Climate Zone 3 (u factor = 0.32). SHGC is not specified in climate zone 3, so a medium gain window with SHGC of 0.40 is assumed.

Deemed Savings for this Measure

$\Delta kWh = SF/100 \times \Delta kWh/100SF$

$\Delta kW_S = SF/100 \times \Delta kW/100SF \times CF_S$

$\Delta MMBTU = SF/100 \times \Delta MMBTU/100SF$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 25 years[265].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $150 per 100 square feet of windows[266].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0.88[267].

[265] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[266] Alliance to Save Energy Efficiency Windows Collaborative Report, December 2007

REFERENCE SECTION

Calculation of Savings

Annual Energy Savings Algorithm

$$\Delta kWh = SF/100 \times \Delta kWh/100SF$$

Where:

SF = area of installed windows
ΔkWh/100SF = unit energy savings from lookup table

Unit energy savings values are provided for each city for a set of HVAC system types. Values are provided for homes with and without cooling, and for homes with gas, heat pump, or electric resistance heating systems.

Installing 200 SF on Energy Star windows in a home in Indianapolis with central AC and gas heat:

$$\Delta kWh = SF/100 \times \Delta kWh/100SF$$
$$= 200/100 \times 38$$
$$= 76 \text{ kWh}$$

Summer Coincident Peak kW Savings Algorithm

$$\Delta kW_S = SF/100 \times \Delta kW/100SF \times CF_S$$

Where:

ΔkW/100SF = unit demand savings from lookup table
CF_S = Summer System Peak Coincidence Factor for Central A/C
= 0.88

Installing 200 SF on Energy Star windows in a home in Indianapolis with central AC and gas heat:

$$\Delta kW_S = SF/100 \times \Delta kW/100SF \times CF_S$$
$$= 200/100 \times .1 \times .88$$
$$= 0.18 \text{ kW}$$

Annual Fossil Fuel Savings Algorithm

$$\Delta MMBTU = SF/100 \times \Delta MMBTU/100SF$$

[267] Duke Energy load shape data for residential AC loads from DSMore cost-effectiveness tool. www.integralanalytics.com

Where:

ΔMMBTU/100SF = unit fossil fuel energy savings from lookup table

Installing 200 SF on Energy Star windows in a home in Indianapolis with central AC and gas heat:

ΔMMBTU = SF/100 x ΔMMBTU/100SF
= 200/100 x 1.07
= 2.14

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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Reference Tables

Indianapolis

HVAC System	kWh/ 100SF	kW/ 100SF	MMBtu/ 100SF
AC Gas Heat	38	0.1	1.07
Heat Pump	1,372	0.2	0
AC Electric Heat	2,393	0.1	0
Electric Heat Only	2,380	0	0
Gas Heat Only	55	0	1.09

South Bend

HVAC System	kWh/ 100SF	kW/ 100SF	MMBtu/ 100SF
AC Gas Heat	60	0.1	1.01
Heat Pump	1,255	0.1	0
AC Electric Heat	2,242	0.1	0
Electric Heat Only	2,246	0	0
Gas Heat Only	50	0	1.01

Evansville

HVAC System	kWh/ 100SF	kW/ 100SF	MMBtu/ 100SF
AC Gas Heat	39	0	0.84
Heat Pump	832	0.1	0
AC Electric Heat	1,806	0.1	0
Electric Heat Only	1,787	0	0
Gas Heat Only	40	0	0.85

Ft Wayne

HVAC System	kWh/ 100SF	kW/ 100SF	MMBtu/ 100SF
AC Gas Heat	38	0	1.1
Heat Pump	1,422	0.1	0
AC Electric Heat	2,425	0	0
Electric Heat Only	2,443	0	0
Gas Heat Only	53	0	1.1

Terre Haute

HVAC System	kWh/ 100SF	kW/ 100SF	MMBtu/ 100SF
AC Gas Heat	53	0.1	0.9
Heat Pump	1,027	0.1	0
AC Electric Heat	1,958	0.1	0
Electric Heat Only	1,949	0	0
Gas Heat Only	43	0	0.9

HVAC System Weighted Average

City	kWh/ 100SF	kW/ 100SF	MMBtu/ 100SF
Indianapolis	564.3	0.0890	0.8158
South Bend	543.0	0.0850	0.7676
Evansville	423.9	0.0220	0.6397
Ft Wayne	573.1	0.0040	0.8360
Terre Haute	471.5	0.0850	0.6840

Residential Two Speed / Variable Speed Pool Pumps (Time of Sale)

Official Measure Code: Res-Pool-Pump-1

Description

This measure describes the purchase and installation of an efficient two-speed or variable speed residential pool pump motor in place of a standard single speed motor of equivalent horsepower.

Definition of Efficient Equipment

The high efficiency equipment is a two-speed or variable speed residential pool pump.

Definition of Baseline Equipment

The baseline efficiency equipment is assumed to be a single speed residential pool pump.

Deemed Savings for this Measure

	Average Annual KWH Savings per unit	Average Summer Coincident Peak kW Savings per unit
Two Speed	436	1.13
Variable Speed	1173	1.74

Deemed Lifetime of Efficient Equipment

The estimated useful life for a variable speed pool pump is 10 years.

Deemed Measure Cost

The incremental cost is estimated to be $175 for a two speed motor and $750 for a variable speed motor[268].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.83[269].

[268] Based on review of Lockheed Martin pump retail price data, July 2009.
[269] Based on Efficiency Vermont's coincidence factor for pool pumps; in the absence of empirical evaluation data, this was based on market feedback about the typical run pattern for pool pumps showing that most people will run pump during the day, and set timer to turn pump off during the night.

Calculation of Savings

Energy Savings [270]

ΔkWh = (HP * LF * 0.746) / ηPump * Hrs/day* Days/yr * ESF

Where:

HP = Horsepower of pump motor
= 1.5
LF = Load factor of pump motor
= 0.66
ηPump = Efficiency of pump motor
= 0.325
Hrs/day = Assumed hours of pump operation per day
= 6 [271]
Days/yr = Assumed number of days pool in use
= 100 days[272]

$ESF_{Two\ Speed}$ = 0.322
$ESF_{Variable\ Speed}$ = 0.86

$\Delta kWh_{Two\ Speed}$ = (1.5 * 0.66 * 0.746) / 0.325 * 6 * 100 * 0.32
= 436 kWh
ΔkWh_{VS} = (1.5 * 0.66 * 0.746) / 0.325 * 6 * 100 * 0.86
= 1173 kWh

Summer Coincident Peak Demand Savings

ΔkW = (HP * LF * 0.746) / ηPump * CF * DSF

Where:
$DSF_{Two\ Speed}$ = 0.59
$DSF_{Variable\ Speed}$ = 0.91

CF = Summer Peak Coincidence Factor for measure
= 0.83[273]

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270 Energy Consumption provided in: Consortium for Energy Efficiency, June 2009; “Pool Pump Exploration Memo”
271 Consortium for Energy Efficiency, June 2009; “Pool Pump Exploration Memo”
272 Assumes pool operation between Memorial Day and Labor Day.

273 Based on Efficiency Vermont’s coincidence factor for pool pumps; in the absence of empirical evaluation data, this was based on market feedback about the typical run pattern for pool pumps showing that most people will run pump during the day, and set timer to turn pump off during the night.

$\Delta kW_{Two\ Speed}$ $= (1.5 * 0.67 * 0.746) / 0.325 * 0.83 * 0.59$
$= 1.13$ kW

$\Delta kW_{Variable\ Speed}$ $= (1.5 * 0.67 * 0.746) / 0.325 * 0.83 * 0.91$
$= 1.74$ kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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Residential Premium Efficiency Pool Pump Motor (Time of Sale)

Official Measure Code: Res-Pool-Motor-1

Description

This measure describes the purchase and installation of a residential 1.5HP premium efficiency single speed pool pump motor in place of a standard single speed motor of equivalent horsepower.

Definition of Efficient Equipment

The high efficiency equipment is a residential 1.5HP premium efficiency single speed pool pump motor.

Definition of Baseline Equipment

The baseline efficiency equipment is a residential 1.5HP standard single speed motor pool pump motor.

Deemed Savings for this Measure

	Average Annual KWH Savings per unit	Average Summer Coincident Peak kW Savings per unit
Premium Efficiency Motor	409	0.58

Deemed Lifetime of Efficient Equipment

The estimated useful life for a pump is 10 years.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $50[274].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.83[275].

274 Franklin Energy Services; "FES- M4 – HE Swimming Pool Pumps – Residential"
275 Based on Efficiency Vermont's coincidence factor for pool pumps; in the absence of empirical evaluation data, this was based on market feedback about the typical run pattern for pool pumps showing that most people will run pump during the day, and set timer to turn pump off during the night.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$kWh_{Base} = (HP * LF_{Base} * 0.746) / \eta Pump_{Base} * Hrs/day_{Base} * Days/yr$
$kWh_{Eff} = (HP * LF_{Eff} * 0.746) / \eta Pump_{Eff} * Hrs/day_{Eff} * Days/yr$

Where [276]

$\Delta kWh = kWh_{Base} - kWh_{Eff}$
HP = Horsepower of motors
= 1.5
LF_{Base} = Load factor of baseline motor
= 0.66
LF_{Eff} = Load factor of efficient motor
= 0.65
$\eta Pump_{Base}$ = Efficiency of baseline motor
= 0.325
$\eta Pump_{Eff}$ = Efficiency of premium efficiency motor
= 0.455
Hrs/day = Assumed hours of pump operation per day
= 6 [277]
Days/yr = Assumed number of days pool in use
= 100 days[278]

$kWh_{Base} = (1.5 * 0.66 * 0.746) / 0.325 * 6 * 100$
= 1,363 kWh

$kWh_{Efficient} = (1.5 * 0.65 * 0.746) / 0.455 * 6 * 100$
= 959 kWh

$\Delta kWh = 1363 - 959$
= 404 kWh

Summer Coincident Peak Demand Savings

$kW_{Base} = (HP * LF_{Base} * 0.746) / \eta Pump_{Base}$
$kW_{Eff} = (HP * LF_{Eff} * 0.746) / \eta Pump_{Eff}$

$\Delta kW = (kW_{Base} - kW_{Eff}) * CF$

276 All assumptions from First Energy's Residential Swimming Pool Pumps memo unless otherwise stated.
277 Consortium for Energy Efficiency, June 2009; "Pool Pump Exploration Memo"
278 Assumes pool operation between Memorial Day and Labor Day.

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.83[279]

kW_{Base} = (1.5 * 0.66 * 0.746) / 0.325
= 2.27 kW

kW_{Eff} = (1.5 * 0.65 * 0.746) / 0.455
= 1.60 kW

ΔkW = (2.27 – 1.60) * 0.83

= 0.56 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[279] Based on Efficiency Vermont's coincidence factor for pool pumps; in the absence of empirical evaluation data, this was based on market feedback about the typical run pattern for pool pumps showing that most people will run pump during the day, and set timer to turn pump off during the night.

Gas Water Heaters (Time of Sale)

Official Measure Code: Res-DHW-StorWH-1

Description

This measure describes the purchase and installation of an efficient gas water heater meeting or exceeding Energy Star criteria[280] for the water heater category.

Definition of Efficient Equipment

The minimum efficiency Energy Star qualification criteria[281] by category are:

Water Heater Type	Energy Factor
Gas Storage	0.67
Gas Condensing	0.80
Gas Tankless (Whole house)	0.82

Definition of Baseline Equipment

New 50 gallon conventional gas storage water heater rated at the federal minimum 0.58 EF.

Deemed Savings for this Measure

ΔMMBtu $= GPD * 365 * 8.3 * \Delta T / 1{,}000{,}000 * ((1/ EF_{Base}) – (1/EF_{Eff}))$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 13 years.[282]

Deemed Measure Cost

Water Heater Type	Incremental Cost[283]
Gas Storage (0.67EF)	$400
Gas Storage Condensing (0.80EF)	$685[284]
Gas Tankless (Whole house)	$605[285]

[280] http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
[281] Though the current standard is 0.62 As of Sept 1 2010 the gas storage specification will change on 9/1/2010, requiring a higher energy factor. The more stringent criteria will save a typical family nearly 15% over a standard model.
[282] For all water heaters, life expectancy will depend on local variables such as water chemistry and homeowner maintenance. There is currently insufficient data to determine tankless water heaters lifetimes. Preliminary data show lifetimes up to 20 years are possible. This value attempts to capture the weighted average lifetime of this category in aggregate and is supported by the findings http://www.aceee.org/consumerguide/WH_LCC_1107.pdf
[283] From EPA Energy Star Water Heater criteria final analysis; the low end of the cited range was used for the tankless category due to age of report.
[284] This value comes from the middle of the range ($1985) of installed costs from the above source minus the $865 installed cost of the baseline. These units are only recently on the market and a review of available pricing support this number.
[285] Uses the same $865 cost baseline, but market review indicated that the incremental cost should be calculated from the low end of the price cited in the source ($1470)

Deemed O&M Cost Adjustments

There is no justification at this time for O&M cost adjustments.

Coincidence Factor

n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔMMBtu $= GPD * 365 * 8.3 * \Delta T / 1{,}000{,}000 * ((1/ EF_{Base}) - (1/EF_{Eff}))$

Where:

GPD = average daily hot water consumption
8.3 = constant (Btu/gal-°F)

Hot water use varies by family size. Estimates of hot water use per person as a function of number of people in the home are shown below.

Number of people	Gal/person-day	Gal/day-household
1	29.4	29
2	22.8	46
3	20.6	62
4	19.5	78
5	18.9	94
6	18.5	111

ΔT = water temperature difference between water heater setpoint and the entering cold water temperature.

Water heater setpoint for residential buildings is usually in the range of 120°F to 140°F. Cold water entering temperatures vary according to climate. Ground water temperature is approximately equal to the annual average temperature, while surface water temperature is approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Groundwater Temperature (°F)	Surface Water Temperature (°F)
Indianapolis	51.9	57.9
South Bend	51.2	57.2
Terre Haute	54.3	60.3
Evansville	56.6	62.6
Ft Wayne	49.5	55.5

EF_{Base} = Energy Factor for the baseline equipment
= 0.594

EF_{Eff} = Energy Factor for the efficient equipment
= actual installed

For example, a new tankless unit rated at AFUE 0.82 is installed in a four person home in Indianapolis. The savings are calculated as follows:

$\Delta MMBtu = GPD * 365 * 8.3 * \Delta T / 1,000,000 * (1/ EF_{Base} - 1/EF_{Eff})$

$= 78 * 365 * 8.3 * (140 – 57.9) / 1000000 * (1 / 0.594 – 1 / 0.82)$

$= 9.0$ MMBtu

Summer Coincident Peak Demand Savings
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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Programmable Thermostats (Time of Sale, Direct Install)

Official Measure Code: Res-HVAC-Tstat-1

Description

Programmable Thermostats can save energy through the advanced scheduling of time-of-day and/or day-of-week setbacks to control heating and cooling setpoints. Typical usage reduces the heating setpoint during times of the day when occupants are usually not at home (work hours), keeping the home at a cooler temperature in the winter; or increases the cooling setpoint during times of the day when occupants are usually not at home (work hours), keeping the home at a warmer temperature in the summer.

Definition of Efficient Equipment

Programmable Thermostat

Definition of Baseline Equipment

Standard, non-programmable thermostat for central cooling and/or heating system (baseboard electric is excluded from this characterization.

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is assumed to be 15 years in accordance with the EPA's determination of the lifetime of the thermostats.

Deemed Measure Cost

The incremental cost for the purchase of a programmable thermostat shows significant variation, but is typically on the order of $35 based upon current retail market prices. Measures directly installed through retrofit programs should use the actual material, and labor costs.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

REFERENCE SECTION

Calculation of Savings

Savings from programmable thermostats can be difficult to estimate from analytical methods due to the significant behavioral interactions in both the initial programming and the year-over year operation. Studies that evaluate the savings impacts of programmable thermostats vary, but there is considerable and credible regard for the findings of a 2007 study[286] that incorporated large sample sizes of survey response and billing analyses.

Energy Savings

Cooling (if central AC or heat pump)

$\Delta kWh = (1/SEER) * FLH_{cool} * BtuH / 1000 * ESF_{cool}$

Where:

SEER = seasonal average energy efficiency ratio (Btu/watt-hour)
= actual. If not available use:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

FLH_{cool} = cooling full-load hours
= from table below

Location	FLH_{cool} [287]
Indianapolis	487
South Bend	431
Evansville	600
Ft. Wayne	373
Terre Haute	569

BtuH = cooling system capacity in Btu/hr
= actual

ESF_{cool} = Cooling energy savings fraction
= 0.09[288]

For example, cooling savings in a home in Indianapolis with a 3 ton 10 SEER heat pump.

$\Delta kWh = (1/SEER) * FLH_{cool} * BtuH / 1000 * ESF_{cool}$

$= 1 / 10 * 487 * 36{,}000 / 1000 * .09$
$= 158$ kWh

Heating (if heat pump or electric furnace)

$\Delta kWh = FLHheat * BtuH / \eta Heat \ / 3412 * ESF_{heat}$

286 2007, RLW Analytics, "Validating the Impact of Programmable Thermostats"
287 Based on prototypical building simulations. See Appendix A.
288 Energy Star website cites 3% savings per degree of setback. ESF assumes 3 degrees of setback.

Where:

FLH_{heat} = heating full-load hours
= from table below

Location	FLH_{heat}[289]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = heating system capacity in Btu/hr
= actual

ηHeat = Efficiency in COP of Heating equipment
= actual. If not available use:

System Type	Age of Equipment	HSPF Estimate	COP Estimate
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	n/a	n/a	1.00

ESF_{heat} = Heating energy savings fraction
= 0.068[290]

For example, heating savings in a home in Indianapolis with 6.8 HSPF heat pump with 100,000 Btu/hr of heating capacity:

$\Delta kWh = FLHheat * BtuH / \eta Heat / 3412 * ESF_{heat}$

$= 1341 * 100{,}000 / 2.0 / 3412 * 0.068$
$= 1336$ kWh

Summer Coincident Peak Demand Savings
n/a

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = FLHheat * BtuH / \eta Heat / 1{,}000{,}000 * ESF_{heat}$

Where:

ηHeat = Efficiency of Heating equipment
= Actual[125]. If not available use 84%[126].

[289] Heating EFLH extracted from simulations. See Appendix A.
[290] 2007, RLW Analytics, "Validating the Impact of Programmable Thermostats"

For example, a home in Indianapolis with a 100,000 Btu/hr 84 AFUE gas furnace:

$$\Delta MMBtu = FLHheat * BtuH / \eta Heat / 1{,}000{,}000 * ESF_{heat}$$
$$= 1341 * 100{,}000 / 0.84 / 1{,}000{,}000 * 0.068$$
$$= 10.9 \text{ MMBtu}$$

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

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Condensing Furnaces-Residential (Time of Sale)

Official Measure Code: Res-HVAC-Furn-1

Description

New ENERGY STAR-qualified high efficiency gas-fired condensing furnace for residential space heating. High efficiency features may include improved heat exchangers and modulating multi-stage burners.

Definition of Efficient Equipment

Furnace AFUE rating ≥ 90% and less than 225,000 BTUh input energy.

Definition of Baseline Equipment

Federal baseline for furnaces is 78%[291]. Review of GAMA shipment data indicates a more suitable market baseline is 80% AFUE. The baseline unit is non-condensing. Early retirement programs the

Deemed Savings for this Measure

$$\Delta MMBtu = FLH_{HEAT} * BtuH * (AFUE_{EFF} / AFUE_{BASE} - 1) * 10^{-6}$$

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is estimated to be 15 years.[292]

Deemed Measure Cost

The incremental measure cost, based on material cost alone[293], as labor is comparable to baseline, shall be related to AFUE of the unit[294]:

AFUE, %	Incremental Cost
90	$310
92	$477
94	$657
96	$851

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

[291] Federal Standards scheduled to take effect 5/2013 will raise furnace efficiency to 90 AFUE in areas with > 5000 heating degree days; and to 80 AFUE in areas with < 5000 heating degree days.
[292] http://www.cee1.org/resrc/facts/gs-ht-fx.pdf
[293] CA DEER Database Res-HVAC
[294] http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf

REFERENCE SECTION

Calculation of Savings
Savings are calculated using the difference in required gas based upon the efficiency of the furnace and the average annual heating load. No change in the distribution system efficiency including fan motor is assumed.

Electrical Energy Savings
n/a

Summer Coincident Peak Demand Savings
n/a

Fossil Fuel Impact Descriptions and Calculation

ΔMMBtu = FLH_{HEAT} * BtuH * ($AFUE_{EFF}$ / $AFUE_{BASE}$ -1) * 10^{-6}

FLH_{HEAT} = Equivalent Full Load Heating Hours
= From table below:

Location	FLH_{heat} [295]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = Size of equipment in Btuh input capacity
= Actual installed

$AFUE_{BASE}$ = Annual Fuel Utilization Efficiency % for the baseline equipment
= 0.80

$AFUE_{EFF}$ = Annual Fuel Utilization Efficiency % for the efficient equipment
= Actual installed

For example: savings for a 100,000 Btu/hr (input) furnace rated at 96 AFUE installed in Indianapolis

ΔMMBtu = 1341 * 100,000 * (0.96/0.80 -1) * 10^{-6}
= 26.8

Water Impact Descriptions and Calculation
n/a

[295] Heating EFLH extracted from simulations. See Appendix A.

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Boilers (Time of Sale)

Official Measure Code: Res-HVAC-Boiler-1

Description

New energy star-qualified high efficiency gas-fired boiler for residential space heating

Definition of Efficient Equipment

Boiler AFUE rating ≥ 85% less than 300,000 BTUh energy input.

Definition of Baseline Equipment

Federal baseline AFUE for boilers is 80 %

Deemed Savings for this Measure

ΔMMBtu $= FLH_{HEAT} * BtuH * (AFUE_{EFF} / AFUE_{BASE} - 1) * 10^{-6}$

Deemed Lifetime of Efficient Equipment

The lifetime of this measure is 18 years[296].

Deemed Measure Cost

The incremental measure cost, based on material and installation costs are a function of the AFUE of the unit:[297]

AFUE	Incremental Cost
85-90	$ 216
≥91	$ 422

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

[296] http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf
[297] http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html values for 85-90

Calculation of Savings

Savings are calculated using the difference in required gas based upon the efficiency of the boiler and the average annual heating load. No changes in the distribution system efficiency including circulator motor are assumed.

Electrical Energy Savings

n/a

Summer Coincident Peak Demand Savings

n/a

Fossil Fuel Impact Descriptions and Calculation

ΔMMBtu $= FLH_{HEAT} * BtuH * (AFUE_{EFF} / AFUE_{BASE} - 1) * 10^{-6}$

FLH_{HEAT} = Equivalent Full Load Heating Hours
= see Table below:

Location	FLH_{heat} [298]
Indianapolis	1341
South Bend	1427
Evansville	982
Ft. Wayne	1356
Terre Haute	804

BtuH = Size of equipment in Btuh input capacity
= Actual installed

$AFUE_{BASE}$ = Annual Fuel Utilization Efficiency % for the baseline equipment
= 0.80

$AFUE_{EFF}$ = Annual Fuel Utilization Efficiency % for the efficient equipment
= Actual installed

For example: savings for a boiler rated at AFUE 85%

ΔMMBtu $= 1341 * 100{,}000 * (0.85/0/80 - 1) * 10^{-6}$
$= 8.4$

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[298] Heating EFLH extracted from simulations. See Appendix A.

Water Heater Wrap (Direct Install)

Official Measure Code: Res-DHW-TankWrap-1

Description

This measure relates to a Tank Wrap or insulation "blanket" that is wrapped around the outside of a hot water tank to reduce stand-by losses. This measure applies only for homes that have an electric water heater that is not already well insulated. Generally this can be determined based upon the appearance of the tank.[299]

Definition of Efficient Equipment

The measure is a properly installed insulating tank wrap to reduce standby energy losses from the tank to the surrounding ambient area.

Definition of Baseline Equipment

The baseline is a standard electric domestic hot water tank without an additional tank wrap. Gas storage water heaters are excluded due to the limitations of retrofit wrapping and the associated impacts on reduced savings and safety.

Deemed Savings for this Measure

	Average Annual KWH Savings per unit	Average Summer Coincident Peak kW Savings per unit	Average Annual Fossil Fuel heating fuel savings (MMBTU) per unit	Average Annual Water savings per unit
Residential	79	0.009	0	0

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 5 years [300].

Deemed Measure Cost

The incremental cost for this measure will be the actual material cost of procuring and labor cost of installing the tank wrap.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

This measure assumes a flat loadshape and as such the coincidence factor is 1.

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[299] Generally this can be determined by the appearance of the tank and whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)

[300] This estimate assumes the tank wrap is installed on an existing unit with 5 years remaining life. On average when retrofitting an existing tank, the tanks would be roughly halfway through their 13-15 year life, but qualifying baseline tanks with fiberglass rather than foam insulation are older by a few years.

Calculation of Savings

This calculation relies upon the findings that a poorly insulated electric resistance water heater with a pre-wrap EF of 0.86 has a new and more effective EF of 0.88 after properly wrapped with supplemental insulation.[301]

Energy Savings

Where:

$\Delta kWH = kWH_{base} * ((EF_{new} - EF_{base})/EF_{new})$

kWH_{base} = Average kWH consumption of electric domestic hot water tank
= 3460 [302]

EF_{new} = Assumed efficiency of electric tank with tank wrap installed
= 0.88 [303]

EF_{base} = Assumed efficiency of electric tank without tank wrap installed
= 0.86.

So:

$\Delta kWH = 3460 * ((0.88-0.86)/0.88)$

$= 79$ kWH

Summer Coincident Peak Demand Savings

$\Delta kW = \Delta kWh/8760$

Where:

ΔkWH = kWH savings from tank wrap installation

8760 = Number of hours in a year (since savings are assumed to be constant over year).

$\Delta kW = 79 / 8760$

$= 0.0090$ kW

[301] Impacts of waste heat on heating and cooling savings are not included in this characterization.

[302] Assumption taken from; Residential Water Heaters Technical Support Document for the January 17, 2001, Final Rule Table 9.3.9, p9-34, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/09.pdf Consistent with FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf

[303] The Oak Ridge study predicted that wrapping a 40 gal water heater would increase Energy Factor of a 0.86 electric DHW tank by 0.02 (to 0.88); "Meeting the Challenge: The Prospect of Achieving 30 percent Energy Savings Through the Weatherization Assistance Program" by the Oak Ridge National Laboratory - May 2002. http://www.cee1.org/eval/db_pdf/309.pdf

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

Solar Water Heater with Electric Backup (Retrofit)

Official Measure Code: Res-DHW-SWH-1

Description

This measure relates to the installation of a new solar water heater system with electric backup meeting SRCC OG-300 performance standards presented below. This measure will relate to the installation of a new system in an existing home.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a SRCC OG-300 certified Solar Water Heater with a solar energy factor (SEF) meeting the ENERGY STAR specification.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a standard electric water heater meeting or exceeding the minimum energy factor set in the 2004 federal conservation standard for water heaters.

Deemed Calculation for this Measure

Annual kWh Savings $= (1/EF - 1/SEF) * Q_{DEL}$

Annual kW Savings $= (1/EF * Q_{DEL}) / Hours * CF$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years [304].

Deemed Measure Cost

The cost for this measure is $9,506[305].

Deemed O&M Cost Adjustments

$344[306]

[304] Based on ENERGY STAR Residential Water Heaters, Final Criteria Analysis: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAn alysis.pdf

[305] The average cost of a fully installed solar thermal system was $9,506, and ranged between $6,825 and $11,850. Source: http://www.greenenergyohio.org/page.cfm?pageID=2712

[306] NPV of future costs including: glycol, pump, and tank replacement. Source: Appendix 2 APS-Incentives for Photovoltaic Distributed Generation (VEIC 2010). Because this retrofit measure replaces an existing water tank with some years remaining, this NPV conservatively overstates the O&M costs to the degree that existing tank would have required replacement a few years earlier.

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 20%[307].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = (1/EF - 1/SEF) * Q_{DEL}$$

Where:

EF = Minimum energy factor for residential electric water heater[308]
= 0.97 - (0.00132 × Rated Storage Volume in gallons)
= 0.904 (50 gallon residential tank)

SEF = Minimum system performance for solar water heaters[309]
= Actual installed

Q_{DEL} = Energy delivered to the hot water load[310]
= GPD * (T * 8.3 BTU/lb-degF
= 41,094 BTU/day
= 4,395 kWh/year[311]

For example, a solar water heater system with SEF rating of 1.8:

ΔkWH = (1/0.9 - 1/1.8) * 4,395 kWh/year
= 2461 kWh

Summer Coincident Peak Demand Savings

$\Delta kW = (1/EF * Q_{DEL} / Hours * CF$

307 Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York.
308 2004 Federal Energy Conservation Standard for water heaters
309 Based on Solar Rating and Certification Company (SRCC) annual system performance rating for solar water heaters (OG-300 7/28/2010). ENERGY STAR specifications require a solar fraction greater than 0.5, which equates to a minimum solar energy factor (SEF) of 1.8.
310 Based on DOE and Solar Rating and Certification Company (SRCC) test procedure assumptions of 64.3 gallons per day draw, 135 deg F hot water and 58 deg F cold water supply temperatures.
311 This baseline level of consumption is higher than the average baseline electrical usage for residential hot water heating (3,460kWh) but less than the consumption level indicated by following the DOE water heating standard test procedure formula: (12.03/EF) x 365 = 4,857kWh. These systems are generally installed in homes with higher usage and correlates with household size and income, and so the calculated value seems appropriate in this light.

Where:

Hours = Full load hours of water heater
= 2533 [312]

CF = Summer Peak Coincidence Factor for measure
= 0.203 [313]

ΔkW = (1/0.9 * 4,395) / 2533 * 0.203
= 0.39 kW[314]

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[312] Full load hours assumption based on Efficiency Vermont loadshape, calculated from Itron eShapes.
[313] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York.
[314] The resultant demand reduction from the Itron eShapes is consistent with the results of the ADM whitepaper for FirstEnergy's solar water heater program in Pennsylvania, in which the demand reduction assumes that the system is designed to meet 100% of a home's hot water need during the summer months and is the product of two factors, the annual baseline energy usage of an electric water heater and the fraction of energy usage during the coincident peak times of 3-6PM during the months of June thru August. The fractional usage was calculated from PJM Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in PJM Region. http://www.pjm.com/~/media/committees-groups/working-groups/lrwg/20070301/20070301-pjm-deemed-savings-report.ashx

Residential New Construction

Official Measure Code: Res-WB-RNC-1

Description

This Residential New Construction (RNC) protocol describes the methodology by which program administrators shall calculate energy and demand savings for new homes built in Indiana. Accredited Home Energy Rating System (HERS) software that complies with the Mortgage Industry National Home Energy Rating Systems Accreditation Standards developed by the Residential Energy Services Network (RESNET) shall be used to calculate energy and demand savings. Likewise, Home Energy Raters (Raters) will follow the technical guidelines provided in the Mortgage Industry National Home Energy Rating Standards when conducting a Rating.

Energy and demand savings shall be estimated per home for heating, cooling, hot water, lighting, ceiling fans, and appliances, including refrigerators and dishwashers. To avoid double-counting of savings, products included in RNC savings should not also be included for savings under another program. However, savings for efficient products installed in the home other than those listed above and that are not claimed through the RNC program may be captured through another program.

Definition of Efficient and Baseline Cases

The following assumptions underlie this methodology:

1. Program implementers are using REM/Rate™ to conduct HERS ratings on each efficient new home built (the Rated Home).
2. Program administrators will employ the User Defined Reference Home (UDRH) feature provided in REM/Rate™ to estimate savings.

The UDRH feature allows energy consumption to be compared for a Rated Home and a User Defined Reference Home (UDRH). The UDRH is an exact replica of the Rated home in size, structure, and climate zone, but the energy characteristics are defined by local code or building practices. Until such a time as a formal study characterizing baseline building practices is completed for Indiana, the UDRH shall be defined by the Residential Energy Efficiency section of the prevailing Indiana Building Code. As of April, 2012 the Indiana Building Code is based on the 2009 International Energy Conservation Code (IECC). Section 0 provides the energy related requirements of the 2009 IECC that shall be used to create the UDRH.

While the assumption is that the HERS software employed by program implementers will be REM/Rate™, any RESNET approved software program may be used. For recommendations on estimating savings using a rating tool other than REM/Rate™, see section titled Other Software (below).

Definitions and Acronyms

HERS - Home Energy Rating System

HERS Provider - A firm or organization that develops, manages, and operates a home energy rating system and is currently accredited by RESNET

Home Energy Rater or Rater – The person trained and certified by a HERS Provider to perform the functions of inspecting and analyzing a home to evaluate the minimum rated features and prepare an energy efficiency rating

IECC - International Energy Conservation Code

Rated Home - The specific home being evaluated using the rating procedures contained in the National Home Energy Rating Technical Guidelines

Rating Tool - A procedure for calculating a home's energy efficiency rating, annual energy consumption, and annual energy costs and which is listed in the "National Registry of Accredited Rating Software Programs" as posted on the RESNET web site

Reference Home - A hypothetical home configured in accordance with the specifications set forth in the National Home Energy Rating Technical Guidelines for the purpose of calculating rating scores

REM/Rate™ **-** RESNET approved residential energy analysis, code compliance and rating software supported by Architectural Energy Corporation, www.archenergy.com

RNC **-** Residential New Construction

RESNET **-** Residential Energy Services Network, the national standards making body for building energy efficiency rating system, www.resnet.us

UDRH - *User Defined Reference Home* is a feature of REM/Rate™ that enables the HERS provider to create other reference buildings based on local construction practice, local code etc. that can be compared to the rated home

Calculation of Savings

Energy Savings

Energy savings, including fossil fuel savings, for heating, cooling, hot water, lighting, and appliances noted above will be a direct output of REM/Rate™ (or other RESNET approved) energy modeling software. Energy savings shall be calculated on a per home basis by the following calculation:

Energy savings = UDRH energy consumption – Rated Home energy consumption

The UDRH shall be defined by the 2009 IECC, with some supplemental clarifications, and is provided in Table 3 in the section titled User Defined Reference Home (UDRH) Specifications below.

For RNC projects that participate through a RESNET-approved sampling protocol, energy savings shall be determined based on the savings from the model home, linearly adjusted based on floor area to all other homes included in that sample set. Chapter 6 of the RESNET Mortgage Industry National Home Energy Rating Standards provides technical guidelines on the sampling protocol.

Demand Savings

Electric demand savings for heating, cooling, hot water, lighting, and appliances are a direct output of REM/Rate™ (or other RESNET approved) energy modeling software. System peak electric demand savings shall be calculated on a per home basis by the following calculation:

Coincident system peak electric demand savings
= (UDRH electric demand – Rated Home electric demand) * CF

Where RNC programs enforce right-sizing of mechanical equipment, the following calculations shall be used:

Coincident system peak electric demand savings
= ((UDRH electric demand * OF*UDRH*) – (Rated Home electric demand * OF*r*)) * CF

Where:

CF = Coincidence factor which equates the installed HVAC system's demand to its demand at time of system peak

OF*UDRH* = Over-sizing factor for the HVAC unit in the UDRH home

OF*r* = Over-sizing factor for the HVAC unit in the Rated Home

Rated Home = Rated Home electric demand output from REM/Rate™

UDRH = User Defined Reference Home electric demand output from REM/Rate™ Table 2 provides a summary of the input values and their data sources.

Table 2. Peak Demand Variable Definitions

Variable	Type	Value	Sources
OFUDRH	Fixed	1.60	PSE&G 1997 Residential New Construction baseline study. 2004 Long Island Power Authority Residential New Construction Technical Baseline Study values of 155% to 172% over-sizing confirms this value.
OF_r	Fixed	1.15	Program guideline for rated home
CF	Fixed	0.50	Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p32

Lighting and Appliances

REM/Rate™ offers two input modes for Lights and Appliances: simplified and detailed. The simplified input mode, or "Lights & Appliances – HERS", is the default mode in REM/Rate™ and is used to calculate a HERS Index. The detailed input mode, or "Lights & Appliances – AUDIT", is used to capture additional lighting and appliance data. Since only the simplified input mode is used when calculating a HERS Index, the simplified mode shall be used when calculating energy and demand savings for RNC.

Energy and demand savings shall be estimated per home for heating, cooling, hot water, lighting, ceiling fans, and appliances, including refrigerators and dishwashers. To avoid double-counting of savings, products included in RNC savings should not also be included for savings under another program. However, savings for efficient products installed in the home other than those listed above and that are not claimed through the RNC program may be captured through another program.

User Defined Reference Home (UDRH) Feature

The UDRH feature in REM/Rate™ provides a home-by-home comparison of energy consumption against a user-defined reference home. REM/Rate™ modifies the thermal and energy performance features of the Rated Home to the specifications provided by the UDRH, leaving the building size, structure and climate zone the same as the Rated Home. The energy consumption of the Rated Home can then be compared to the energy consumption of the same home had it been built to different specifications.

The UDRH shall be defined by the Residential Energy Efficiency section of the prevailing Indiana Building Code. As of April, 2012 the Indiana Building Code is based on the 2009 International Energy Conservation Code (IECC). Therefore, energy and demand savings in Indiana will be based on the difference in estimated energy consumption of the program home, and that same home had it been built to 2009 (or any subsequently-updated) IECC specifications.

For REM/Rate™, the UDRH specifications are contained in an ASCII script file that follows a specific syntax. Details on creating a UDRH file can be found in the REM/Rate™ Help module. Inputs for a UDRH file based on 2009 IECC (with supplemental clarifications) can be found in Table 3 in the section titled User Defined Reference Home (UDRH) Specifications below.

A UDRH report may be run singly for each home, or in batch mode for multiple homes. Data from the UDRH report may also be exported from REM/Rate™ to an Access database for additional data manipulation and to calculate savings. Additional information on using the UDRH batch export feature can be found in the REM/Rate™ Help module.

Indiana Climate Zones

Climate zones from Figure 1 shall be used in determining the applicable energy requirements for the UDRH. Details of the UDRH are listed in Table 3.

Figure 1. Indiana Climate Zones Map

User Defined Reference Home (UDRH) Specifications

Table 3 below provides inputs for a UDRH based on the 2009 IECC, with some supplemental clarifications.

Table 3. 2009 IECC UDRH Specifications

Data Point	Value		Unit	Source	Comment
Building Thermal Envelope					
	Zone 4	Zone 5			
Fenestration	0.40	0.35	U-factor	2009 IECC Table 402.1.3	
Skylight	0.60	0.60	U-factor	2009 IECC Table 402.1.3	
Glazed Fenestration SHGC	0.40	0.40	SHGC	2009 IECC Table 404.5.2(1)	No prescriptive requirement.
Ceiling	.030	.030	U-factor	2009 IECC Table 402.1.3	
Wood Frame Wall	.082	.060	U-factor	2009 IECC Table 402.1.3	
Rim and Band Joists	.082	.060	U-factor		Code requirement for wood frame wall.
Mass Wall	.141	.082	U-factor	2009 IECC Table 402.1.3	
Frame Floor	.047	.033	U-factor	2009 IECC Table 402.1.3	
Basement Wall	.059	.059	U-factor	2009 IECC Table 402.1.3	
Slab, unheated	10, 2	10, 2	R-value, ft	2009 IECC Table 402.1.1	"ft" = feet from top of slab edge below grade.
Slab, heated	15, 2	15, 2	R-value, ft	2009 IECC Table 402.1.1	"ft" = feet from top of slab edge below grade.
Crawl Space Wall	.065	.065	U-factor	2009 IECC Table 402.1.3	
Air Infiltration Rate	.00036	.00036	SLA	2009 IECC Table 404.5.2(1)	Approximately 7 to 8 ACH50.
Mechanical Systems					
Furnace	80		AFUE	Federal Standard	Standard is 78 AFUE, 80 AFUE is adopted based on typical minimum availability and practice.
Boiler	80		AFUE	Federal Standard	
Heat Pump, Heating	7.7		HSPF	Federal Standard	All heat pumps shall be characterized as an ASHP.
Central Air Conditioning	13		SEER	Federal Standard	
Heat Pump, Cooling	13		SEER	Federal Standard	
Water Heating, gas	0.58		EF	Federal Standard	Federal requirements vary based on tank size. The UDRH feature does not allow adjustments to efficiency values based on tank size, therefore the UDRH reference efficiency shall be based on minimum federal efficiency requirements for a 50 gal
Water Heating, oil	0.50		EF	Federal Standard	See Water Heating, gas.
Water heating, electric	0.90		EF	Federal Standard	See Water Heating, gas.

Data Point	Value	Unit	Source	Comment
Integrated Space/Water Heating, heating	80	AFUE	Federal Standard, Boiler	Combination space and water heating units shall reference the minimum Federal standard boiler efficiency for the heating portion of the unit
Integrated Space/Water Heating, water	.58 (gas) .50 (oil) .90 (electric)	EF	Federal Standard, Water heating	Combination space and water heating units shall reference the minimum Federal standard water heating efficiency for the water heating portion of the
Thermostat, type	Manual		2009 IECC Table 404.5.2(1)	
Thermostat, cooling set point	78	Degree F	2009 IECC Table 404.5.2(1)	
Thermostat, heating set point	68	Degree F	2009 IECC Table 404.5.2(1)	
Duct Insulation	8	R-value	2009 IECC 403.2.1	
Duct Insulation, in floor truss	6	R-Value	2009 IECC 403.2.1	
Duct Leakage	0.80	DSE	2009 IECC Table 404.5.2(1)	
Mechanical Ventilation	n/a			Ventilation is not required by code. The UDRH shall not reference ventilation. This way the program home will
Lights & Appliances				
Efficient Lighting	10	Percent	RESNET Standard	
Refrigerator	585	kWh/yr	VEIC	Based on the weighted average of NAECA baseline kWh/yr installed in Vermont, 5000 hr/yr.
Dishwasher	0.46	EF	RESNET Standard	
Ceiling Fan	None		RESNET Standard	

Active Solar & Photovoltaics (PV)

Solar systems installed for water and/or space heating and photovoltaic systems installed to meet electricity demand are not addressed in the 2006 IECC. However, they need to be addressed in the UDRH. If the RNC program **allows** for savings to be claimed from the use of active solar or PV systems, these systems should eliminated from the UDRH so that their savings shows up when compared to the rated home with the solar system installed.

If the RNC program **does not allow** savings to be claimed from the use of active solar or PV systems, these systems should not be included in the UDRH. When a system is not referenced in the UDRH, that system will be the same in both the Rated and the Reference home. This way, energy consumption for the Rated Home and the UDRH will be estimated assuming both configurations have the solar or PV system installed, so no savings will be reported. The specific syntax for this is provided in the REM/Rate™ UDRH Syntax Report.

Other Software

If the program implementer is using a RESNET approved software program other than REM/Rate™, where possible a module similar to the UDRH feature in REM/Rate™ shall be used to estimate energy and demand savings. If no such feature exists, the following steps shall be taken to estimate energy and demand savings:

1. Model the home in a RESNET approved software program and capture energy consumption and electric demand.
2. Model the same home a second time using the 2009 UDRH specifications provided in Table 3 and capture energy consumption and electric demand.
3. The difference between energy consumption in the Rated Home and the Rated Home modeled to 2009 IECC specifications shall be the energy savings for that home.
4. The difference between electric demand in the Rated Home and the Rated Home modeled to 2009 IECC specifications shall be the electric demand savings for that home.

Savings from lighting and appliances shall be estimated using the alternate RESNET approved software. Any appliances not captured by the alternate software program shall be captured by a program other than RNC.

Deemed Lifetime of Efficient Building

25 yr (for heating, cooling, and shell savings measures)[315]

Deemed Measure Cost

Incremental costs can be calculated for different tiers of efficient homes from the following table.

[315] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007; http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Table 4. Incremental Costs from Baseline to Specific HERS Levels[316]

	ENERGY STAR Minimum (HERS 85)*	HERS 70	HERS 65
Single Family Home with Gas Furnace total and per square foot cost	\$2,869 \$1.18	\$7,136 \$2.94	\$9,286 \$3.83
Single Family Home with Gas Boiler total and per square foot cost	\$2,646 \$1.09	\$6,570 \$2.71	\$8,160 \$3.36
Single Family Home with Oil Boiler total and per square foot cost	\$2,371 \$0.98	\$6,325 \$2.61	\$7,914 \$3.26
Average for all single family total and per square foot cost	\$2,599 \$1.07	\$6,677 \$2.75	\$8,453 \$3.49

*Calculated as an average of the packages provided for each housing type/HVAC system combination

Deemed O&M Cost Adjustments

There are no operation and maintenance cost adjustments for this measure

Fossil Fuel Impact Descriptions and Calculation

Energy savings, including fossil fuel savings, for heating, cooling, hot water, lighting, and appliances noted above will be a direct output of REM/Rate™ (or other RESNET approved) energy modeling software as described above

Water Impact Descriptions and Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[316] Evaluation of the Massachusetts New Homes with Energy Star® Program, Incremental Cost Analysis Nexus Market Research, Inc. and Dorothy Conant, Nov. 2007

Whole-House Residential Retrofit

Official Measure Code: Res-WB-WWRetro-1

Description

Whole house retrofit programs, like Home Performance with ENERGY STAR and Low Income Weatherization initiatives may include a variety of treatments, including building shell and HVAC upgrades and the direct installation of energy efficient products. This protocol describes how building energy modeling of each individual home treated through a program may be used to estimate savings for the building shell (e.g., air-sealing and insulation) and HVAC (e.g., duct sealing and central heating and/or cooling system replacements) measures installed in those homes. Savings from other measures such as efficient lighting, appliances, or water heating should be estimated using deemed values or deemed calculations provided for such measures elsewhere in this TRM.

The alternative to using building energy modeling to develop energy savings for the shell and HVAC measures would be to use the deemed measure savings calculations found elsewhere in this TRM for the installed measures (air-sealing, insulation, duct sealing, etc.). Deemed savings calculations are simpler to administer and implement but may be less precise because they are based on some assumed average characteristics of homes (e.g., average heating system efficiencies) and do not capture interactive effects between some measures.

Definition of Efficient Case

House as treated by installed building shell and HVAC measures. Installed measures outside of these categories should follow the appropriate measure-specific characterizations.

Definition of Baseline Case

The baseline is the house as it is before it is retrofitted with installed measures. The only exception to this rule is that the assumed baseline efficiency of a heating system or central air conditioner that is being replaced should be consistent with the current minimum federal efficiency standards for such equipment, unless it is clear that the equipment would not have been replaced at that particular point in time were it not for the influence of the program (i.e., the program must document that old equipment would otherwise not have been replaced in order to claim a baseline efficiency that is lower than current minimum federal efficiency standards).

Calculation of Savings

The requirements for a model-based approach to savings claims are in part are delineated through adherence with at least one of the following national standards for whole-house savings calculations:

- RESNET[317] approved rating software
- Software energy simulation performance exceeding the requirements of National Renewable Energy Laboratory's Home Energy Rating System BESTEST[318]
- US DOE Weatherization Assistance Program approval[319]

[317] http://resnet.us
[318] http://www.nrel.gov/docs/legosti/fy96/7332b.pdf
[319] http://www.waptec.org

Proper savings estimates from modeling software also require that the R-value of uninsulated walls or ceilings (i.e., baseline conditions) should be modeled as being no less than R-5. In addition, software tools must be calibrated against actual consumption data for each treated home or from a sample sized for 90% confidence interval and 10% margin of error statistical precision. These requirements address concerns that modeling software can over-estimates savings, particularly cooling savings.

The software tools must provide outputs that separately account for heating and cooling energy and peak demand savings so that demand and fuel-related economic savings may be properly addressed.

Deemed Lifetime of Efficient Case

The average savings-weighted lifetime for this measure is assumed to be 20 years, based upon an anticipated mixture of shell and HVAC measures that range from 15 to 25 years.[320]

Deemed Measure Cost

The total of the actual costs in procuring and installing the equipment, materials, and/or services.

Deemed O&M Cost Adjustments

n/a

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[320] A review of actual measures installed through the program should be conducted to assess whether on a savings basis the weighted average should be adjusted in accordance with a measure distribution that favors longer (insulation) or shorter (air sealing) lifetimes.

III. Commercial & Industrial Market Sector

Electric Chiller (Time of Sale)

Official Measure Code: CI-HVAC-chiller-1

Description

This measure relates to the installation of a new electric chiller meeting the efficiency standards presented below. This measure could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in an existing building (i.e. time of sale). Only single-chiller applications should be assessed with this methodology. Multiple chiller projects should be evaluated on a custom basis.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to exceed the efficiency requirements of ASHRAE Standard 90.1-2007 Table 6.8.1.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements of the ASHRAE Standard 90.1-2007 Table 6.8.1.

Deemed Calculation for this Measure

Annual kWh Savings = TONS * ((3.516/$IPLV_{base}$) – (3.516/$IPLV_{ee}$)) * EFLH

Summer Coincident Peak kW Savings = TONS * ((3.516/COP_{base}) – (3.516/COP_{ee})) * CF

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years [321].

Deemed Measure Cost

The incremental capital cost for this measure is provided below.

[321] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls)

Equipment Type	Size Category	IPLV	COP	Incremental Cost ($/ton)
Air-Cooled Electrically Operated	All Capacities	3.36	3.08	$58.58
		3.66	3.36	$106.23
Water-Cooled Screw Chiller	<150 Ton	5.58	4.95	$55.63
		6.28	5.58	$111.25
	150 - 300 Ton	6.17	5.41	$39.76
		6.89	6.17	$79.52
	>300 Ton	6.89	6.06	$27.94
		7.64	6.89	$55.87
Water-Cooled Centrifugal Chiller	<150 Ton	5.86	5.58	$83.05
		6.63	6.28	$166.10
	150 - 300 Ton	6.51	6.17	$61.44
		7.33	6.89	$122.87
	>300 Ton	7.18	6.76	$46.11
		7.99	7.64	$92.22

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 74%[322].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWH = TONS * ((3.516/$IPLV_{base}$) – (3.516/$IPLV_{ee}$)) * EFLH

Where:

TONS = chiller nominal cooling capacity in tons (note: 1 ton = 12,000 Btu/h)
= Actual installed

3.516 = conversion factor to express Integrated Part Load Value (IPLV) in terms of kW per ton

$IPLV_{base}$ = efficiency of baseline equipment expressed as Integrated Part Load Value. Dependent on chiller type. See Table A in the Reference Tables section.

[322] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

IPLVee[323]	= efficiency of high efficiency equipment expressed as Integrated Part Load Value
	= Actual installed
EFLH	= equivalent full load hours

Dependent on location and building type as below:

Building	System	Indianapolis	South Bend	Evansville	Ft. Wayne	Terre Haute
Community College	CAV no econ	1,314	1,090	1,632	1,124	1,320
	CAV econ	966	840	1,167	821	955
	VAV econ	736	621	881	642	680
Hotel	CAV no econ	3,999	3,766	4,424	3,999	4,240
	CAV econ	3,786	3,541	4,238	3,786	4,034
	VAV econ	3,732	3,480	4,161	3,732	3,899
Large Retail	CAV no econ	2,065	1,899	2,243	2,006	2,164
	CAV econ	1,289	1,118	1,545	1,183	1,405
	VAV econ	1,065	904	1,297	969	1,196
University	CAV no econ	1,927	1,805	2,140	1,958	1,833
	CAV econ	727	739	917	754	682
	VAV econ	950	927	1,157	884	795
Large Office	CAV no econ	3,302	2,786	3,300	3,107	3,197
	CAV econ	876	897	1,118	916	981
	VAV econ	992	864	1,042	801	999
High School	CAV no econ	1,039	1,003	1,125	995	979
	CAV econ	558	519	696	513	570
	VAV econ	426	359	505	397	383
Hospital	CAV no econ	3,777	3,199	4,267	3,538	3,870
	CAV econ	2,182	1,830	2,684	1,997	2,416
	VAV econ	1,554	1,365	1,860	1,442	1,746

Summer Coincident Peak Demand Savings

ΔkW = TONS * ((3.516/COP_{base}) – (3.516/COP_{ee})) * CF

Where:

COP_{base} = efficiency of baseline equipment expressed as COP

Dependent on chiller type. See Table A in the Reference Tables section.

COP_{ee}	= efficiency of high efficiency equipment expressed as COP
	= Actual installed
CF	= Summer Peak Coincidence Factor for measure
	= 74%

323 Integrated Part Load Value is simply a seasonal average efficiency rating calculated in accordance with ARI Standard 550/590. It may be calculated using any measure of efficiency (EER, kW/ton, COP), but for consistency with IECC 2006, it is expressed in terms of COP here.

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Reference Tables

Table A: Baseline Efficiency Values by Chiller Type and Capacity[324]

Equipment Type	Size Category	Baseline Efficiency (IPLVbase, COPbase)
Air cooled, with condenser, electrically operated	All capacities	3.05 IPLV, 2.80 COP
Air cooled, without condenser, electrically operated	All capacities	3.45 IPLV, 3.10 COP
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	5.05 IPLV, 4.20 COP
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	5.20 IPLV, 4.45 COP
	>= 150 tons and < 300 tons	5.60 IPLV, 4.90 COP
	>= 300 tons	6.15 IPLV, 5.50 COP
Water cooled, electrically operated, centrifugal	< 150 tons	5.25 IPLV, 5.00 COP
	>= 150 tons and < 300 tons	5.90 IPLV, 5.55 COP
	>= 300 tons	6.40 IPLV, 6.10 COP

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[324] ASHRAE 90.1-2007 Table 6.8.1B.

Chiller Tune-Up

Official Measure Code: CI-HVAC-ChillerTune-1

Description

This section covers the tune-up of an existing air or water cooled chiller. The tune-up consists of tube cleaning, chilled and condenser water temperature adjustments, and reciprocating compressor unloading switch adjustments.

Definition of Efficient Equipment

Existing chiller post tune-up

Definition of Baseline Equipment

Existing chiller pre tune-up

Deemed Calculation for this Measure

$\Delta kWH = TONS * (3.516/IPLV_{base}) * EFLH * 0.08$

$\Delta kW = TONS * (3.516/COP_{base}) * 0.74 * 0.08$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 years

Deemed Measure Cost

The incremental cost for this measure is assumed to be

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

The summer peak coincidence factor for this measure is 0.74

REFERENCE SECTION

Calculation of Savings

$\Delta kWH = TONS * (3.516/IPLV_{base}) * EFLH * ESF$

Where:

TONS = chiller nominal cooling capacity in tons (note: 1 ton = 12,000 Btu/h)
= Actual installed

3.516 = conversion factor to express Integrated Part Load Value (IPLV) in terms of kW per ton

$IPLV_{base}$ = efficiency of existing equipment expressed as Integrated Part Load Value. Dependent on chiller type. See Table A in the Reference Tables section.

ESF = 0.08

EFLH = equivalent full load hours

Dependent on location and building type[325] as below:

Building	System	Indianapolis	South Bend	Evansville	Ft. Wayne	Terre Haute
Community College	CAV no econ	1,314	1,090	1,632	1,124	1,320
	CAV econ	966	840	1,167	821	955
	VAV econ	736	621	881	642	680
Hotel	CAV no econ	3,999	3,766	4,424	3,999	4,240
	CAV econ	3,786	3,541	4,238	3,786	4,034
	VAV econ	3,732	3,480	4,161	3,732	3,899
Large Retail	CAV no econ	2,065	1,899	2,243	2,006	2,164
	CAV econ	1,289	1,118	1,545	1,183	1,405
	VAV econ	1,065	904	1,297	969	1,196
University	CAV no econ	1,927	1,805	2,140	1,958	1,833
	CAV econ	727	739	917	754	682
	VAV econ	950	927	1,157	884	795
Large Office	CAV no econ	3,302	2,786	3,300	3,107	3,197
	CAV econ	876	897	1,118	916	981
	VAV econ	992	864	1,042	801	999
High School	CAV no econ	1,039	1,003	1,125	995	979
	CAV econ	558	519	696	513	570
	VAV econ	426	359	505	397	383
Hospital	CAV no econ	3,777	3,199	4,267	3,538	3,870
	CAV econ	2,182	1,830	2,684	1,997	2,416
	VAV econ	1,554	1,365	1,860	1,442	1,746

For example, kWh savings for the tune-up of a 300 ton chiller with an IPLV of 6.0 serving an office with a VAV system in Indianapolis is calculated from:

$$\Delta kWh = TONS * (3.516/IPLV_{base}) * EFLH * ESF$$
$$= 300 * (3.516 / 6.0) * 992 * 0.08$$
$$= 12{,}967 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = TONS * (3.516/COP_{base}) * CF * DSF$$

[325] EFLH data derived from building energy simulation models. See Appendix A.

Where:

COP_{base} = efficiency of baseline equipment expressed as COP. Dependent on chiller type. See Table A in the Reference Tables section.
CF = Summer Peak Coincidence Factor for measure
= 74%
DSF = demand savings factor
= 0.08

For example, kW savings for the tune-up of a 300 ton chiller with a COP of 5.0 is calculated from:

$$\Delta kW = TONS * (3.516/COP_{base}) * CF * DSF$$
$$= 300 *(3.516 / 5) * 0.74 * 0.08$$
$$= 12.45 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation

N/A

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

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Referenced Tables:

Table A: Baseline Efficiency Values by Chiller Type and Capacity[326]

Equipment Type	Size Category	Baseline Efficiency (IPLVbase, COPbase)
Air cooled, with condenser, electrically operated	All capacities	3.05 IPLV, 2.80 COP
Air cooled, without condenser, electrically operated	All capacities	3.45 IPLV, 3.10 COP
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	5.05 IPLV, 4.20 COP
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	5.20 IPLV, 4.45 COP
	>= 150 tons and < 300 tons	5.60 IPLV, 4.90 COP
	>= 300 tons	6.15 IPLV, 5.50 COP
Water cooled, electrically operated, centrifugal	< 150 tons	5.25 IPLV, 5.00 COP
	>= 150 tons and < 300 tons	5.90 IPLV, 5.55 COP
	>= 300 tons	6.40 IPLV, 6.10 COP

[326] ASHRAE 90.1-2007 Table 6.8.1B.

C&I Lighting Controls (Time of Sale, Retrofit)

Official Measure Code: CI-Ltg-Control-1

Description

This measure relates to the installation of a new lighting control on a new or existing lighting system. Lighting control types covered by this measure include wall- or ceiling-mounted occupancy sensors, fixture mounted occupancy sensors, remote-mounted daylight dimming sensors, fixture mounted daylight dimming sensors, central lighting controls (timeclocks), and switching controls for multi-level lighting. This measure could relate to the installation of a new system in an existing building or a new construction application (i.e., time of sale). Lighting controls required by state energy codes are not eligible.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a lighting system controlled by one of the lighting controls systems listed above.

Definition of Baseline Equipment

The baseline equipment is assumed to be an uncontrolled lighting systems operated by a manual switch.

Deemed Calculation for this Measure

Annual kWh Savings = kWcontrolled * HOURS * (1 + WHFe) * ESF

Summer Coincident Peak kW Savings

= kWcontrolled * (1 + WHFd) * ESF * CF

Deemed Lifetime of Efficient Equipment

The expected measure life for all lighting controls is assumed to be 8 years [327].

Deemed Measure Cost

The incremental capital cost for this measure is provided below.

Lighting Control Type	Incremental Cost
Wall-Mounted Occupancy Sensors	$42 [328]
Ceiling-Mounted Occupancy Sensors	$66 [329]
Fixture Mounted Occupancy Sensors	$125 [330]
Remote-Mounted Daylight Dimming Sensors	$65 [331]

[327] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls)

[328] Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.

[329] Ibid.

[330] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010.

Lighting Control Type	Incremental Cost
Fixture Mounted Daylight Dimming Sensors	$50[332]
Switching Controls for Multi-Level Lighting	$274[333]
Central Lighting Controls (Timeclocks)	$103[334]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is dependent on technology type as below:

Lighting Control Type	CF
Wall- or Ceiling-Mounted Occupancy	0.15[335]
Fixture-Mounted Occupancy Sensors	0.15[336]
Remote-Mounted Daylight Dimming	0.90[337]
Fixture-Mounted Daylight Dimming Sensors	0.90[338]
Switching Controls for Multi-Level Lighting	0.77[339]
Central Lighting Controls (Timeclocks)	0.00[340]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = kW_{controlled} * HOURS * (1 + WHFe) * ESF$$

Where:

$kW_{controlled}$ = total lighting load connected to the control in kilowatts
= Actual installed

HOURS = total operating hours of the controlled lighting before the lighting controls are installed. Use site-specific operating hours from audit report or

[331] Ibid.
[332] Ibid.
[333] Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.
[334] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Cost Values and Summary Documentation”, California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip)
[335] Coincidence Factor Study Residential and Commercial Industrial Lighting Measures, RLW Analytics, Spring 2007.
[336] Ibid.
[337] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.
[338] Ibid.
[339] Ibid.
[340] Conservative assumption based on professional judgment considering that timeclocks are unlikely to produce significant savings during the summer on-peak period.

application if available. If site-specific data not available, assume default values dependent on building type as below:

Building Type	HOURS	Source
Food Sales	5,544	OH TRM[341]
Food Service	3,357	Duke OH[342] + NC[343]
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM
Exterior	4,300	OH TRM
Other	4,408	Duke OH

WHFe = lighting-HVAC Interaction Factor for energy; this factor represents the reduced electric space cooling requirements due to the reduction on waste heat rejected by the efficient lighting. See Appendix B. Set zero if exterior lighting.

ESF = Energy Savings Factor; percent operating hours reduced due to the installation of the occupancy lighting controls or timeclocks, or percent wattage reduction multiplied by the hours of dimming for dimming lighting controls and multilevel switching.

[341] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

[342] Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2010.

[343] Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2011.

Dependent on control type as below:

Lighting Control Type	ESF[344]
Wall- or Ceiling-Mounted Occupancy	30%
Fixture-Mounted Occupancy Sensors	30%
Remote-Mounted Daylight Dimming	30%
Fixture-Mounted Daylight Dimming Sensors	30%
Switching Controls for Multi-Level Lighting	30%
Central Lighting Controls (Timeclocks)	10%

Summer Coincident Peak Demand Savings

$\Delta kW = kW_{connected} * (1 + WHFd) * ESF * CF$

Where:

WHFd = lighting-HVAC Interaction Factor for demand; this factor represents the reduced electric space cooling requirements due to the reduction on waste heat rejected by the efficient lighting. See Appendix B. Set zero if exterior lighting.

CF = Summer Peak Coincidence Factor for measure

Dependent on control type as presented in the introductory "Coincidence Factor" section.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = \Delta kWh * WHFg$

Where:

WHFg = lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B. Set zero if exterior lighting.

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

[344] Energy Savings Factors determined from a review of Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, TecMarket Works, September 1, 2009, Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

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Lighting Systems (Non-Controls) (Time of Sale, New Construction)

Official Measure Code: CI-Ltg-FixtRep-NC-1

Description

This measure relates to the installation of new lighting equipment with efficiency that exceeds that of equipment that would have been installed following standard market practices. This characterization includes compact fluorescent lamps (CFLs) and fixtures, linear fluorescent lamps and fixtures, linear fluorescent fixtures replacing high-intensity discharge (HID) fixtures in high-bay applications, and high- intensity discharge (HID) fixtures. This measure could relate to the replacement of an existing unit at the end of its useful life or the installation of a new unit in a new or existing facility.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment must have higher efficiency than the existing equipment and meet program specific equipment criteria.

Definition of Baseline Equipment

The assumed baseline equipment varies by technology type.

Compact Fluorescent Lamps

Deemed Calculation for Compact Fluorescent Lamps

This measure relates to the installation of a new ENERGY STAR certified compact fluorescent screw-in lamp (CFL) (for those equipment types for which an ENERGY STAR category exists). This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new unit in a new or existing building (i.e. time of sale). This measure applies to the installation of a screw-in CFL replacing a standard general service incandescent lamp.

Annual kWh Savings[345] = $(WATTS_{ee} * 2.79) * HOURS * (1 + WHF_e) / 1000$

Summer Coincident Peak kW Savings = $(WATTS_{ee} * 2.79) * CF * (1 + WHF_d) / 1000$

Note: The multiplier should be adjusted according to the table below to account for the change in baseline stemming from the Energy Independence and Security Act of 2007 discussed below:

[345] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010. Source document cites several evaluations indicating that the overall average existing incandescent lamp wattage is 75.7W and the overall average replacement wattage is 20.0W for CFLs <= 32W. For the purposes of this characterization, it is assumed that the baseline and efficient wattages are directly proportional. These assumptions have been simplified as follows: (WATTSbase – WATTSee) = [(75.7/20.0)* WATTSee] – WATTSee = WATTSee * 2.79.

CFL Wattage	Delta Watts Multiplier[346]		
	2012	2013	2014 and Beyond
15 or less	2.79	2.79	1.72
16-20	2.79	1.68	1.68
21W+	1.73	1.73	1.73

Baseline Adjustment for Compact Fluorescent Lamps

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[347]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for this measure must be reduced for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. For example, for 100W equivalent bulbs (21W+ CFLs) installed in 2010, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[348]:

CFL Wattage	Savings as Percentage of Base Year		
	2012	2013	2014 and Beyond
15 or less	100%	100%	62%
16-20	100%	60%	60%
21W+	62%	62%	62%

Deemed O&M Cost Adjustment Calculation for Compact Fluorescent Lamps

In order to account for the shift in baseline due to the Federal Legislation discussed above, the levelized baseline replacement cost over the lifetime of the CFL is calculated. The key assumptions used in this calculation are documented below:

[346] Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

[347] http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

[348] Calculated by finding the ratio of delta watt savings before and after the legislation change (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

	Standard Incandescent	Efficient Incandescent
Replacement Cost	$0.50	$2.00
Component Life (years) (based on lamp life / assumed annual run hours)	0.27[349]	0.81[350]

The calculated net present value of the baseline replacement costs for CFL type and installation year are presented below:

CFL wattage	NPV of baseline Replacement		
	2012	2013	2014 on
21W+	$7.50	$7.50	$7.50
16-20W	$6.91	$7.50	$7.50

CFL wattage	NPV of baseline Replacement		
	2012	2013	2014 on
15W and less	$6.34	$6.91	$7.50

Compact Fluorescent Fixtures

Deemed Calculation for Compact Fluorescent Fixtures

This measure relates to the installation of a new ENERGY STAR certified compact fluorescent lamp (CFL) fixture (for those equipment types for which an ENERGY STAR category exists). This measure could relate to the replacing of an existing unit at the end of its useful life, typically during a major renovation, or the installation of a new system in a new or existing building (i.e. time of sale). This measure applies to the installation of a pin-based CFL fixture (including modular lamp and ballast) replacing a standard general service incandescent lamp.

Annual kWh Savings[351] = $(WATTS_{ee} * 2.79) * HOURS * (1 + WHF_e) / 1000$

Summer Coincident Peak kW Savings = $(WATTS_{ee} * 2.79) * CF * (1 + WHF_d) / 1000$

Note: The multiplier should be adjusted according to the table below to account for the change in baseline stemming from the Energy Independence and Security Act of 2007 discussed below:

349 Assumes rated life of incandescent bulb of approximately 1000 hours.
350 Best estimate of future technology from OH TRM.
351 Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010. Source document cites several evaluations indicating that the overall average existing incandescent lamp wattage is 75.7W and the overall average replacement wattage is 20.0W for CFLs <= 32W. For the purposes of this characterization, it is assumed that the baseline and efficient wattages are directly proportional. These assumptions have been simplified as follows: (WATTSbase – WATTSee) = [(75.7/20.0)* WATTSee] – WATTSee = WATTSee * 2.79.

CFL Wattage	Delta Watts Multiplier[352]		
	2012	2013	2014 and Beyond
15 or less	2.79	2.79	1.72
16-20	2.79	1.68	1.68
21W+	1.73	1.73	1.73

Baseline Adjustment for Compact Fluorescent Fixtures

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs, in essence beginning the phase out of standard incandescent bulbs[353]. In 2012 100W incandescents will no longer be manufactured, followed by restrictions on 75W in 2013 and 60W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the first year annual savings for 100W equivalent bulbs (21W+ CFLs) in 2012, for 75W equivalent bulbs (16-20W CFLs) in 2013 and for 60 and 40W equivalent bulbs (15W or less CFLs) in 2014. To account for this adjustment the delta watt multiplier is adjusted as shown above. In addition, since during the lifetime of a CFL, the baseline incandescent bulb will be replaced multiple times, the annual savings claim must be reduced within the life of the measure. For example, for 100W equivalent bulbs (21W+ CFLs) installed in 2010, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life.

The appropriate adjustments as a percentage of the base year savings for each CFL range are provided below[354]:

CFL Wattage	Savings as Percentage of Base Year		
	2012	2013	2014 and Beyond
15 or less	100%	100%	62%
16-20	100%	60%	60%
21W+	62%	62%	62%

Deemed O&M Cost Adjustment Calculation for Compact Fluorescent Fixtures

Conservatively not included

352 Calculated by finding the new delta watts after incandescent bulb wattage reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

353 http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

354 Calculated by finding the ratio of delta watt savings before and after the legislation change (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W in 2014).

High Bay Fluorescent Fixtures

Deemed Calculation for High Bay Fluorescent Fixtures

The assumed baseline for installation of a high bay fluorescent fixture is a metal halide system. The Energy Independence and Security Act of 2007 (EISA) requires that as of January 1, 2009, metal halide fixtures designed for use with lamps ≥150 W and ≤500 W must use "probe start" ballasts with ballast efficiency ≥94% or "pulse start" ballasts with ballast efficiency ≥88. It is therefore likely that new metal halide fixtures will utilize "pulse start" technology. Therefore, the assumed baseline system is a magnetic ballast "pulse start" metal halide system.

Annual kWh Savings = $(WATTS_{base} – WATTS_{ee})$ * HOURS * $(1 + WHF_e)$ / 1000

Summer Coincident Peak kW Savings = (WATTSbase – WATTSee) * CF * (1 + WHFd) / 1000

See Table 5 for $WATTS_{base}$ and $WATTS_{ee}$ values.

Deemed O&M Cost Adjustment Calculation for High Bay Fluorescent Fixtures

O&M cost adjustments were developed assuming a typical baseline system and two typical efficient equipment scenarios. For T5HO High Bay fixtures replacing pulse start metal halide fixtures, the levelized annual baseline replacement cost assumption is calculated as $5.87. For T8VHO high bay fixtures replacing pulse start metal halide fixtures, the levelized annual baseline replacement cost assumption is calculated as -$1.69. The assumptions used to calculate these adjustments are detailed below.

Baseline 320W Metal-Halide Lamp Cost:	$25.00
Baseline 320W Lamp Life:	15,000 hrs
Baseline Lamp Labor Cost:	$5.00 (15 min @ $20 per hour labor)
Baseline 320W Ballast Cost:	$60.00
Baseline Ballast Life:	40,000
Baseline Ballast Labor Cost:	$22.50 (30 min @ $45 per hour labor)
T5 High-Bay Lamp Cost:	$5 per lamp (assumes 4 lamps fixture) T5
High-Bay Lamp Life:	20,000 hrs
T5 High-Bay Lamp Labor Cost:	$6.67 (20 min @ $20 per hour labor) T5
High-Bay Ballast Cost:	$51.00
T5 High-Bay Ballast Life:	70,000 hrs
T5 High-Bay Ballast Labor Cost:	$22.50 (30 min @ $45 per hour labor)
T8 High-Bay Lamp Cost:	$10 per lamp (assumes 6 lamp fixture)
T8 High-Bay Lamp Life:	18,000 hrs
T8 High-Bay Lamp Labor Cost:	$13.33 (40 min @ $20 per hour labor) T8
High-Bay Ballast Cost:	$100.00 (2 ballasts)
T8 High-Bay Ballast Life:	70,000 hrs
T8 High-Bay Ballast Labor Cost:	$45 (60 min @ $45 per hour labor)

High Efficiency Linear Fluorescent Fixtures

Deemed Calculation for High Efficiency Fluorescent Fixtures

The assumed baseline for installation of a fluorescent fixture varies by the efficient system installed. High Performance and Reduced Wattage T8s must comply with the requirements as published by the Consortium for Energy Efficiency[355].

$$\text{Annual kWh Savings} = (WATTS_{base} - WATTS_{ee}) * HOURS * (1 + WHF_e) / 1000$$

$$\text{Summer Coincident Peak kW Savings} = (WATTS_{base} - WATTS_{ee}) * CF * (1 + WHF_d) / 1000$$

See Table 5 for $WATTS_{base}$ and $WATTS_{ee}$ values.

Baseline Adjustment

The U.S. Department of Energy issued on June 26, 2009 a final rule, amending the energy conservation standards[356,357] for equipment types, baseline lamps will become unavailable and participants will be required to upgrade both lamps and ballasts to High Performance T8s, thus negating any savings. Assuming a typical lamp has a lifetime of 18,000 hours and is operated 3,730 hours per year, new lamps installed shortly before the impending federal standards take effect will need to be replaced in mid-2017, indicating that savings should be claimed for only 7 years for measures installed in 2010. This baseline adjustment has been incorporated into the measure life for the applicable equipment types.

Deemed O&M Cost Adjustment Calculation
Conservatively not included

Metal Halide Track Lighting

Deemed Calculation for Metal Halide Track Lighting

A metal-halide track head produces equal or more light as compared to halogen track head(s), while using fewer watts. This measure applies to the installation of a metal halide track head replacing (a) halogen track head(s).

$$\text{Annual kWh Savings} = (WATTS_{base} - WATTS_{ee}) * HOURS * (1 + WHF_e) / 1000$$

$$\text{Summer Coincident Peak kW Savings} = (WATTS_{base} - WATTS_{ee}) * CF * (1 + WHF_d) / 1000$$

See Table 6 for $WATTS_{base}$ and $WATTS_{ee}$ values.

[355] The Consortium for Energy Efficiency publishes the High Performance T8 Specifications and the Reduced Wattage T8 Specifications periodically including a list of qualifying equipment at the following address: http://www.cee1.org/com/com-lt/com-lt-main.php3
[356] Neubauer, M., Ka-BOOM! The Power of Appliance Standards Opportunities for New Federal Appliance and Equipment Standards, ACEEE, July 2009.
[357] For more information, see "http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf."

Ceramic Metal Halide Fixtures

Deemed Calculation for Ceramic Metal Halide Fixtures

Ceramic Metal-Halide is a new type of metal-halide that provides excellent light quality with a high color- rendering index. It is typically used in place of halogen bulb(s) in applications that require excellent light quality and/or tight beam control. Ceramic Metal-Halide bulbs have high lumen output, and thus can replace multiple halogen fixtures.

Annual kWh Savings = $(WATTS_{base} – WATTS_{ee}) * HOURS * (1 + WHF_e) / 1000$

Summer Coincident Peak kW Savings = $(WATTS_{base} – WATTS_{ee}) * CF * (1 + WHF_d) / 1000$

See Table 7 for $WATTS_{base}$ and $WATTS_{ee}$ values.

Deemed O&M Cost Adjustment Calculation for Ceramic Metal Halide Fixtures

O&M cost adjustments were developed assuming a typical baseline and efficient equipment scenario. For ceramic metal halide fixtures replacing halogen fixtures, the levelized annual baseline replacement cost assumption is calculated as $24.29. The assumptions used to calculate these adjustments are detailed below.

Baseline 75W Halogen Lamp Cost:	$30.00 (3 lamps)
Baseline 75W Halogen Lamp Life:	2,500 hrs
Baseline 75W Halogen Lamp Labor Cost:	$2.67
70W CMH Lamp Cost:	$60
70W CMH Lamp Life:	12,000 hrs
70W CMH Lamp Labor Cost:	$2.67
70W CMH Ballast Cost:	$90
70W CMH Ballast Life:	40,000 hrs
70W CMH Ballast Labor Cost:	$22.50 (30 min @ $45 per hour labor)

Deemed Lifetime of Efficient Equipment

The expected measure life is dependent on technology type as below:

Technology Type	Lifetime
Screw-in CFL	3.2 years[358]
CFL Fixture	12 years[359]
High Bay Fluorescent Fixture	15 years[360]
High Efficiency Linear Fluorescent Fixtures – 4ft	15 years[361]
High Efficiency Linear Fluorescent Fixtures – all	15 years[362]
Metal Halide Track Lighting	15 years[363]
Ceramic Metal Halide	15 years[364]

Deemed Measure Cost

The incremental capital costs for this measure vary by the assumed baseline and efficient equipment scenarios. Incremental costs by measure type are presented below:

Measure Type	Incremental Cost
Screw-in CFL	$3[365]
CFL Fixture (1-lamp)	$35[366]
CFL Fixture (2-lamp)	$40[367]
High Bay Fluorescent Fixture	$150[368]
High Efficiency Linear Fluorescent Fixture	25[369]
20 Watt Ceramic Metal Halide	$130[370]
39 Watt Ceramic Metal Halide	$130
50 Watt Ceramic Metal Halide	$95
70 Watt Ceramic Metal Halide	$95
100 Watt Ceramic Metal Halide	$90
150 Watt Ceramic Metal Halide	$90
20 Watt Metal Halide Track	$155
39 Watt Metal Halide Track	$155
70 Watt Metal Halide Track	$145

Coincidence Factor

The summer peak coincidence factor for this measure is dependent on building type as below:

[358] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010. Assumes 12,000 hours lamp lifetime with extended burn times per start typical in commercial applications. Assuming 3,730 annual lighting operating hours for the commercial sector from the source document, the lamp lifetime is calculated as: 12,000 / 3,730 = 3.2 years

[359] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008

[360] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[361] See discussion in measure's "Baseline Adjustment" section.

[362] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

[363] Ibid.

[364] Ibid.

[365] Based on review of TRM assumptions from Vermont, New York, New Jersey and Connecticut.

[366] Based on review of TRM assumptions from Vermont, New York, California, and Northwestern states.

[367] Ibid.

[368] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[369] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, p. 110 (incremental costs vary from $20 to $27.50 for 1 to 4 lamps).

[370] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. This document is the source for all subsequent incremental cost estimates presented in the table.

Building Type	CF[371]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel Guest Room	0.37
Hotel/Motel Common Areas	0.90
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[372]
Exterior	0.00[373]
Other	0.65

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = (WATTS_{base} - WATTS_{ee}) * HOURS * (1 + WHF_e) / 1000$$

Where:

$WATTS_{base}$ = connected wattage of the baseline fixtures
= Assumed baseline wattage for time of sale application. See corresponding measure table for default values.

$WATTS_{ee}$ = connected wattage of the high efficiency fixtures
= Actual installed

HOURS = annual operating hours of the lighting. Use site-specific operating hours from audit report or application if available. If site-specific data not available, assume default values dependent on building type as below:

371 Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

372 Assumption consistent with 8,760 operating hours assumption.

373 Assumes that no exterior lighting is operating during the summer on-peak demand period.

Building Type	HOURS	Source
Food Sales	5,544	OH TRM[374]
Food Service	3,357	Duke OH[375] + NC[376]
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM
Exterior	4,300	OH TRM
Other	4,408	Duke OH

WHFe = lighting-HVAC Interation Factor for energy; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

1 / 1000 = conversion factor from watts to kilowatts

Summer Coincident Peak Demand Savings

$\Delta kW = (WATTS_{base} – WATTS_{ee}) * CF * (1 + WHF_d) / 1000$

Where:

WHFd = lighting-HVAC waste heat factor for demand; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

CF = Summer Peak Coincidence Factor for measure

Dependent on building type as below:

374 Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

375 Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2010.

376 Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2011.

Building Type	CF[377]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[378]
Exterior	0.00[379]
Other	0.65

Fossil Fuel Impact Descriptions and Calculation

ΔMMBtu = ΔkWh * WHFg

Where:

WHFg = lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting.
= See Appendix B.

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
See the individual technology sections above.

[377] Methodology adapted from Kuiken et al, “State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development”, KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.
[378] Assumption consistent with 8,760 operating hours assumption.
[379] Assumes that no exterior lighting is operating during the summer on-peak demand period.

Reference Tables

Calculation of O&M Impact for Baseline

Measure Life	3.22
Real Discount Rate (RDR	5.00%

Bulb Assumptions	Inc	Halogen
Component 1 Life (years)	0.27	0.81
Component 1 Replacement Cost	$1.87	$2.46

2010

		Year	NPV	2010	2011	2012	2013
21W+	Baseline Replacement Costs		$6.34	$1.87	$1.87	$2.46	$0.54
16-20W	Baseline Replacement Costs		$5.80	$1.87	$1.87	$1.87	$0.54
15W and less	Baseline Replacement Costs		$5.69	$1.87	$1.87	$1.87	$0.41

2011

		Year	NPV	2011	2012	2013	2014
21W+	Baseline Replacement Costs		$6.91	$1.87	$2.46	$2.46	$0.54
16-20W	Baseline Replacement Costs		$6.34	$1.87	$1.87	$2.46	$0.54
15W and less	Baseline Replacement Costs		$5.80	$1.87	$1.87	$1.87	$0.54

2012

		Year	NPV	2012	2013	2014	2015
21W+	Baseline Replacement Costs		$7.50	$2.46	$2.46	$2.46	$0.54
16-20W	Baseline Replacement Costs		$6.91	$1.87	$2.46	$2.46	$0.54
15W and less	Baseline Replacement Costs		$6.34	$1.87	$1.87	$2.46	$0.54

2013

		Year	NPV	2013	2014	2015	2016
21W+	Baseline Replacement Costs		$7.50	$2.46	$2.46	$2.46	$0.54
16-20W	Baseline Replacement Costs		$7.50	$2.46	$2.46	$2.46	$0.54
15W and less	Baseline Replacement Costs		$6.91	$1.87	$2.46	$2.46	$0.54

	NPV of baseline Replacement Costs				
CFL wattage	2010	2011	2012	2013	2014 on
21W+	$6.34	$6.91	$7.50	$7.50	$7.50
16-20W	$5.80	$6.34	$6.91	$7.50	$7.50
15W and less	$5.69	$5.80	$6.34	$6.91	$7.50

Table 5. High Bay Fixture Baseline and Efficient Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
High Bay	T-5 46" Two Lamp High Output	Electronic - PRS	150W Pulse Start Metal Halide	Magnetic-CWA	117	4	183	4	66
High Bay	T-5 46" Three Lamp High Output	Electronic - PRS	200W Pulse Start Metal Halide	Magnetic-CWA	181	4	232	3	51
High Bay	T-5 46" Four Lamp High Output	Electronic – IS	320W Pulse Start Metal Halide	Magnetic-CWA	234	3	365	3	131
High Bay	T-5 46" Six Lamp High Output	Electronic – IS	350W Pulse Start Metal Halide	Magnetic-CWA	351	3	400	3	49
High Bay	T-5 46" Eight Lamp High Output	Electronic – IS	1000W Pulse Start Metal Halide	Magnetic-CWA	468	3	1080	3	612
High Bay	T-5 46" Six Lamp High Output (2 Fixtures)	Electronic – IS	1000W Pulse Start Metal Halide	Magnetic-CWA	702	3	1080	3	378
High Bay	T-8 48" Two Lamp Very High Output	Electronic – IS	150W Pulse Start Metal Halide	Magnetic-CWA	77	4	183	4	106
High Bay	T-8 48" Three Lamp Very High Output	Electronic – IS	150W Pulse Start Metal Halide	Magnetic-CWA	112	3	183	4	71
High Bay	T-8 48" Four Lamp Very High Output	Electronic – IS	200W Pulse Start Metal Halide	Magnetic-CWA	151	3	232	3	81
High Bay	T-8 48" Six Lamp Very High Output	Electronic – IS	320W Pulse Start Metal Halide	Magnetic-CWA	226	3	365	3	139
High Bay	T-8 48" Eight Lamp Very High Output	Electronic - PRS	350W Pulse Start Metal Halide	Magnetic-CWA	288	4	400	3	112
High Bay	T-8 48" Eight Lamp Very High Output (2 Fixtures)	Electronic – PRS	1000W Pulse Start Metal Halide	Magnetic-CWA	576	4	1080	3	504

Table 6: High Efficiency Fluorescent (HEF) Fixture Baseline and Efficient Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTSee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTSbase)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
HEF	T-8 24" One Lamp	Electronic	T-12 24" One Lamp	Magnetic-STD	18	3	24	3	6
HEF	T-8 24" Two Lamp	Electronic	T-12 24" Two Lamp	Magnetic-STD	32	3	56	3	24
HEF	T-8 24" Three Lamp	Electronic	T-12 24" Three Lamp	Magnetic-STD	50	3	62	3	12
HEF	T-8 24" Four Lamp	Electronic	T-12 24" Four Lamp	Magnetic-STD	65	3	112	3	47
HEF	T-8 36" One Lamp	Electronic	T-12 36" One Lamp	Magnetic-STD	25	3	46	3	21
HEF	T-8 36" Two Lamp	Electronic	T-12 36" Two Lamp	Magnetic-STD	46	3	81	3	35
HEF	T-8 36" Three Lamp	Electronic	T-12 36" Three Lamp	Magnetic-STD	70	3	127	3	57
HEF	T-8 36" Four Lamp	Electronic	T-12 36" Four Lamp	Magnetic-STD	88	3	162	3	74
HEF	Reduced Wattage T-8 48" One Lamp-28W	Electronic – IS	T-8 48" One Lamp	Electronic - IS	23.3	2	31	3	7.7
HEF	Reduced Wattage T-8 48" Two Lamp-28W	Electronic – IS	T-8 48" Two Lamp	Electronic - IS	47	2	59	3	12
HEF	Reduced Wattage T-8 48" Three Lamp-28W	Electronic – IS	T-8 48" Three Lamp	Electronic - IS	69.9	2	89	3	19.1
HEF	Reduced Wattage T-8 48" Four Lamp-28W	Electronic – IS	T-8 48" Four Lamp	Electronic - IS	92.6	2	112	3	19.4
HEF	Reduced Wattage T-8 48" One Lamp-25W	Electronic – IS	T-8 48" One Lamp	Electronic - IS	22	2	31	3	9
HEF	Reduced Wattage T-8 48" Two Lamp-25W	Electronic – IS	T-8 48" Two Lamp	Electronic - IS	41	2	59	3	18
HEF	Reduced Wattage T-8 48" Three Lamp-25W	Electronic – IS	T-8 48" Three Lamp	Electronic - IS	61.3	2	89	3	27.7
HEF	Reduced Wattage T-8 48" Four Lamp-25W	Electronic – IS	T-8 48" Four Lamp	Electronic - IS	80.5	2	112	3	31.5
HEF	T-8 96" One Lamp	Electronic – IS	T-12 96" One Lamp-ES	Magnetic-STD	58	3	75	3	17
HEF	T-8 96" Two Lamp	Electronic – IS	T-12 96" Two Lamp-ES	Magnetic-ES	109	3	123	3	14
HEF	T-8 96" Four Lamp	Electronic – IS	T-12 96" Four Lamp-ES	Magnetic-ES	219	3	246	3	27
HEF	High Performance T-8 48" One Lamp	Electronic	T-8 48" One Lamp	Electronic - IS	25	6	31	3	6
HEF	High Performance T-8 48" Two Lamp	Electronic	T-8 48" Two Lamp	Electronic - IS	48	6	59	3	10
HEF	High Performance T-8 48" Three Lamp	Electronic	T-8 48" Three Lamp	Electronic - IS	73	6	89	3	17
HEF	High Performance T-8 48" Four Lamp	Electronic	T-8 48" Four Lamp	Electronic - IS	96	6	112	3	18

Table 7. Metal Halide Track (MHT) Lighting Baseline and Efficient Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTSee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTSbase)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
MHT	Metal Halide 20W		Two 50W Halogen		23	1	100	1	77
MHT	Metal Halide 39W		Two 75W Halogen		43	1	150	1	107
MHT	Metal Halide 70W		Three 75W Halogen		77	1	225	1	148

Table 8. Ceramic Metal Halide (CMH) Baseline and Efficient Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTSee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTSbase)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
CMH	Ceramic Metal Halide 20W		Two 50W Halogen		26	1	100	1	74
CMH	Ceramic Metal Halide 39W		Two 75W Halogen		45	1	150	1	105
CMH	Ceramic Metal Halide 50W		Three 65W Halogen		55	1	195	1	140
CMH	Ceramic Metal Halide 70W		Three 75W Halogen		79	1	225	1	146
CMH	Ceramic Metal Halide 100W		Three 90W Halogen		110	1	270	1	160
CMH	Ceramic Metal Halide 150W		Three 120W Halogen		163	1	360	1	197

Table 9. Low and High Bay LED Lighting

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTSee	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTSbase)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
LBLED	Low Bay LED 85 W3		Metal Halide 250 W		85		295		210
LBLED	Low Bay LED 85 W3		T-8 96" Two Lamp High Output	Electronic	85		160		75
HBLED	High Bay LED 139W		Metal Halide 200W		139		232		93
HBLED	High Bay LED 175W		Metal Halide 250W		175		295		120

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Referenced Documents:

1. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
2. Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.
3. 2010 Standard Performance Contract Procedures Manual: Appendix B: 2010 Table of Standard Fixture Wattages. Ver. 1.1, Southern California Edison. February 25, 2010. Web. Accessed June, 19 2010. <http://www.aesc-inc.com/download/SPC/2010SPCDocs/UnifiedManual/App%20B%20Standard%20Fixture%20Watts.pdf>
4. 2009 EPE Program Downloads. Wattage Table 2009. Web. Accessed September, 26 2009. <http://www.epelectricefficiency.com/downloads.asp?section=ci>.
5. New Jersey Clean Energy Program: Protocols to Measure Resource Savings. December 2007.
6. Thorne and Nadel, Commercial Lighting Retrofits: A Briefing Report for Program Implementers, American Council for an Energy- Efficient Economy, April 2003.

Lighting Systems (Non-Controls) (Early Replacement, Retrofit)

Official Measure Code: CI-Ltg-FixtRep-ER-1

Description

This measure relates to the installation of new lighting equipment with efficiency that exceeds that of the existing equipment. This characterization could apply to measures such as compact fluorescent lamps (CFLs) and fixtures, linear fluorescent lamps and fixtures, linear fluorescent fixtures replacing high-intensity discharge (HID) fixtures in high-bay applications, high-intensity discharge (HID) fixtures, and delamping. This measure could relate to the early replacement of an existing unit before the end of its useful life or the retrofit of a unit in an existing facility.

Note: See Lighting Systems (Non-Controls) (Time of Sale, New Construction) section above for calculation procedures for commercial screw-in CFLs and CFL fixtures.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment must have higher efficiency than the existing equipment.

Definition of Baseline Equipment

The baseline equipment is the existing equipment before the efficient equipment is installed. Default assumptions of the baseline equipment are presented in the tables below.

Deemed Calculation for this Measure

Annual kWh Savings = ($WATTS_{base}$ – $WATTS_{ee}$) * HOURS * (1 + WHF_e) / 1000

Summer Coincident Peak kW Savings = ($WATTS_{base}$ – $WATTS_{ee}$) * CF * (1 + WHF_d) / 1000

Deemed Lifetime of Efficient Equipment

The expected measure life is dependent on technology type as below:

Measure Type	Lifetime
Screw-in CFL	3.2 years[380]
Hardwired CFL	12 years[381]
High Bay Fluorescent Fixture	7 years[382]
High Efficiency Linear Fluorescent Fixture	15 years[383]
Pulse Start Metal Halide	7.5 years[384]
Metal Halide Track Lighting	5 years[385]
Ceramic Metal Halide	15 years[386]
Delamping	10[387]

Deemed Measure Cost

The actual lighting measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments

O&M cost adjustments should be determined on a case-by-case basis.

[380] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010. Assumes 12,000 hours lamp lifetime with extended burn times per start typical in commercial applications. Assuming 3,730 annual lighting operating hours for the commercial sector from the source document, the lamp lifetime is calculated as: 12,000 / 3,730 = 3.2 years

[381] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008

[382] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[383] Ibid.

[384] The Energy Independence and Security Act of 2007 requires that as of January 1, 2009, metal halide fixtures designed for use with lamps ≥150 W and ≤500 W must use “probe start” ballasts with ballast efficiency ≥94% or “pulse start” ballasts with ballast efficiency ≥88%. This essentially means that new metal halide fixtures will utilize “pulse start” technology. Assuming that the age of the existing equipment being replaced is half of the total expected lifetime for a metal halide fixture (7.5 years), it is assumed that savings are only achieved for half of the lifetime of the new fixture at which point the customer would have had to replace the inefficient technology with “pulse start” technology negating any savings.

[385] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[386] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[387] Based on a review of measure life assumptions in Oregon, California, and Iowa as presented in Measure Life Study, Energy & Resource Solutions, November 17, 2005, delamping lifetime assumptions range from 9 to 16 years. The high end or this range exceeds the assumed fixture lifetime and has been adjusted down to a more conservative 10 years to reflect expected persistence issues.

Coincidence Factor

The summer peak coincidence factor for this measure is dependent on building type as below:

Building Type	CF[388]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel Guest Room	0.37
Hotel/Motel Common Area	0.90
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[389]
Exterior	0.00[390]
Other	0.65

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = (WATTS_{base} – WATTS_{ee}) * HOURS * (1 + WHF_e) / 1000$$

Where:

$WATTS_{base}$ = connected wattage of the baseline fixtures
= Actual wattage of the existing equipment for early replacement application. If actual wattage is unknown, refer to the Baseline and Efficient Fixture Wattages Table in the Reference Table section.

$WATTS_{ee}$ = connected wattage of the high efficiency fixtures
= Actual wattage of the efficient equipment for early replacement application. If actual wattage is unknown, refer to the Baseline and Efficient Fixture Wattages Table in the Reference Table section.

388 Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

389 Assumption consistent with 8,760 operating hours assumption.

390 Assumes that no exterior lighting is operating during the summer on-peak demand period.

HOURS = annual operating hours of the lighting. Use site-specific operating hours from audit report or application if available. If site-specific data not available, assume default values dependent on building type as below:

Building Type	HOURS	Source
Food Sales	5,544	OH TRM[391]
Food Service	3,357	Duke OH[392] + NC[393]
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM
Exterior	4,300	OH TRM
Other	4,408	Duke OH

WHF_e = lighting-HVAC Interation Factor for energy; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

1 / 1000 = conversion factor from watts to kilowatts

Summer Coincident Peak Demand Savings

$$\Delta kW = (WATTS_{base} - WATTS_{ee}) * CF * (1 + WHF_d) / 1000$$

Where:

WHFd = lighting-HVAC waste heat factor for demand; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

CF = Summer Peak Coincidence Factor for measure

Dependent on building type as below:

391 Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

392 Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2010.

393 Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2011.

Building Type	CF[394]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel Guest Room	0.37
Hotel/Motel Common Area	0.90
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[395]
Exterior	0.00[396]
Other	0.65

Fossil Fuel Impact Descriptions and Calculation

ΔMMBtu = ΔkWh * WHFg

Where:

WHFg = lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

Water Impact Descriptions and Calculation

n/a

[394] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

[395] Assumption consistent with 8,760 operating hours assumption.

[396] Assumes that no exterior lighting is operating during the summer on-peak demand period.

Reference Tables

Table 10. Baseline and Efficient Fixture Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
High Bay	T-5 46" Two Lamp High Output	Electronic - PRS	175W Metal Halide	Magnetic-CWA	117	4	208	3	91
High Bay	T-5 46" Three Lamp High Output	Electronic - PRS	175W Metal Halide	Magnetic-CWA	181	4	208	3	27
High Bay	T-5 46" Four Lamp High Output	Electronic – IS	400W Metal Halide	Magnetic-CWA	234	3	458	3	224
High Bay	T-5 46" Six Lamp High Output	Electronic – IS	400W Metal Halide	Magnetic-CWA	351	3	458	3	107
High Bay	T-5 46" Eight Lamp High Output	Electronic – IS	1000W Metal Halide	Magnetic-CWA	468	3	1080	3	612
High Bay	T-5 46" Six Lamp High Output (2 Fixtures)	Electronic – IS	1000W Metal Halide	Magnetic-CWA	702	3	1080	3	378
High Bay	T-8 48" Two Lamp Very High Output	Electronic – IS	150W Metal Halide	Magnetic-CWA	77	4	190	3	113
High Bay	T-8 48" Three Lamp Very High Output	Electronic – IS	150W Metal Halide	Magnetic-CWA	112	3	190	3	78
High Bay	T-8 48" Four Lamp Very High Output	Electronic – IS	250W Metal Halide	Magnetic-CWA	151	3	295	3	144
High Bay	T-8 48" Six Lamp Very High Output	Electronic – IS	400W Metal Halide	Magnetic-CWA	226	3	458	3	232
High Bay	T-8 48" Eight Lamp Very High Output	Electronic - PRS	400W Metal Halide	Magnetic-CWA	288	4	458	3	170
High Bay	T-8 48" Eight Lamp Very High Output (2 Fixtures)	Electronic – PRS	1000W Metal Halide	Magnetic-CWA	576	4	1080	3	504
HEF	T-8 24" One Lamp	Electronic	T-12 24" One Lamp	Magnetic-STD	18	3	24	3	6
HEF	T-8 24" Two Lamp	Electronic	T-12 24" Two Lamp	Magnetic-STD	32	3	56	3	24
HEF	T-8 24" Three Lamp	Electronic	T-12 24" Three Lamp	Magnetic-STD	50	3	62	3	12
HEF	T-8 24" Four Lamp	Electronic	T-12 24" Four Lamp	Magnetic-STD	65	3	112	3	47
HEF	T-8 36" One Lamp	Electronic	T-12 36" One Lamp	Magnetic-STD	25	3	46	3	21
HEF	T-8 36" Two Lamp	Electronic	T-12 36" Two Lamp	Magnetic-STD	46	3	81	3	35
HEF	T-8 36" Three Lamp	Electronic	T-12 36" Three Lamp	Magnetic-STD	70	3	127	3	57
HEF	T-8 36" Four Lamp	Electronic	T-12 36" Four Lamp	Magnetic-STD	88	3	162	3	74
HEF	T-8 48" One Lamp-28W	Electronic - IS	T-12 48" One Lamp-ES	Magnetic-ES	23.3	2	43	3	19.7
HEF	T-8 48" Two Lamp-28W	Electronic - IS	T-12 48" Two Lamp-ES	Magnetic-ES	47	2	72	3	25
HEF	T-8 48" Three Lamp-28W	Electronic - IS	T-12 48" Three Lamp-ES	Magnetic-ES	69.9	2	115	3	45.1

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
HEF	T-8 48" Four Lamp-28W	Electronic - IS	T-12 48" Four Lamp-ES	Magnetic-ES	92.6	2	144	3	51.4
HEF	T-8 48" One Lamp-25W	Electronic - IS	T-12 48" One Lamp-ES	Magnetic-ES	22	2	43	3	21
HEF	T-8 48" Two Lamp-25W	Electronic - IS	T-12 48" Two Lamp-ES	Magnetic-ES	41	2	72	3	31
HEF	T-8 48" Three Lamp-25W	Electronic - IS	T-12 48" Three Lamp-ES	Magnetic-ES	61.3	2	115	3	53.7
HEF	T-8 48" Four Lamp-25W	Electronic - IS	T-12 48" Four Lamp-ES	Magnetic-ES	80.5	2	144	3	63.5
HEF	T-8 96" One Lamp	Electronic - IS	T-12 96" One Lamp-ES	Magnetic-STD	58	3	75	3	17
HEF	T-8 96" Two Lamp	Electronic - IS	T-12 96" Two Lamp-ES	Magnetic-ES	109	3	123	3	14
HEF	T-8 96" Four Lamp	Electronic - IS	T-12 96" Four Lamp-ES	Magnetic-ES	219	3	246	3	27
HEF	High Performance T-8 48" One Lamp	Electronic	T-12 48" One Lamp-ES	Magnetic-ES	25	6	43	3	18
HEF	High Performance T-8 48" Two Lamp	Electronic	T-12 48" Two Lamp-ES	Magnetic-ES	48	6	72	3	23
HEF	High Performance T-8 48" Three Lamp	Electronic	T-12 48" Three Lamp-ES	Magnetic-ES	73	6	115	3	43
HEF	High Performance T-8 48" Four Lamp	Electronic	T-12 48" Four Lamp-ES	Magnetic-ES	96	6	144	3	50
MHT	Metal Halide 20W		Two 50W Halogen		23	1	100	1	77
MHT	Metal Halide 39W		Two 75W Halogen		43	1	150	1	107
MHT	Metal Halide 70W		Three 75W Halogen		77	1	225	1	148
CMH	Ceramic Metal Halide 20W		Two 50W Halogen		26	1	100	1	74
CMH	Ceramic Metal Halide 39W		Two 75W Halogen		45	1	150	1	105
CMH	Ceramic Metal Halide 50W		Three 65W Halogen		55	1	195	1	140
CMH	Ceramic Metal Halide 70W		Three 75W Halogen		79	1	225	1	146
CMH	Ceramic Metal Halide 100W		Three 90W Halogen		110	1	270	1	160
CMH	Ceramic Metal Halide 150W		Three 120W Halogen		163	1	360	1	197
Delamp	No Lamp	Magnetic-STD	T-12 18” One Lamp	Magnetic-STD	4	TBD	19	3	15
Delamp	No Lamp	No Ballast	T-12 18” One Lamp	Magnetic-STD	0	TBD	19	3	19
Delamp	No Lamp	Magnetic-STD	T-12 24” One Lamp	Magnetic-STD	8	TBD	28	3	20
Delamp	No Lamp	No Ballast	T-12 24” One Lamp	Magnetic-STD	0	TBD	28	3	28
Delamp	No Lamp	Magnetic-STD	T-12 36” One Lamp	Magnetic-STD	16	TBD	46	3	30
Delamp	No Lamp	No Ballast	T-12 36” One Lamp	Magnetic-STD	0	TBD	46	3	46
Delamp	No Lamp	Magnetic-STD	T-12 48” One Lamp	Magnetic-STD	21	TBD	60	3	39

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
Delamp	No Lamp	No Ballast	T-12 48” One Lamp	Magnetic-STD	0	TBD	60	3	60
Delamp	No Lamp	Magnetic-STD	T-12 60” One Lamp	Magnetic-STD	13	TBD	63	3	50
Delamp	No Lamp	No Ballast	T-12 60” One Lamp	Magnetic-STD	0	TBD	63	3	63
Delamp	No Lamp	Magnetic-STD	T-12 72” One Lamp	Magnetic-STD	21	TBD	76	3	55
Delamp	No Lamp	No Ballast	T-12 72” One Lamp	Magnetic-STD	0	TBD	76	3	76
Delamp	No Lamp	Magnetic-STD	T-12 96” One Lamp	Magnetic-STD	15	TBD	90	TBD	75
Delamp	No Lamp	No Ballast	T-12 96” One Lamp	Magnetic-STD	0	TBD	90	TBD	90
Delamp	T-8 24” One Lamp	Electronic – IS	T-8 24” Two Lamp	Electronic - IS	16	TBD	33	TBD	17
Delamp	T-8 36” One Lamp	Electronic – IS	T-8 36” Two Lamp	Electronic - IS	21	TBD	46	TBD	25
Delamp	T-8 48” One Lamp	Electronic – IS	T-8 48” Two Lamp	Electronic - IS	27	TBD	59	TBD	32
Delamp	T-8 60” One Lamp	Electronic – IS	T-8 60” Two Lamp	Electronic - IS	32	TBD	72	TBD	40
Delamp	T-8 96” One Lamp	Electronic – IS	T-8 96” Two Lamp	Electronic - IS	50	TBD	109	TBD	59

Sources:

1. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
2. Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.
3. 2010 Standard Performance Contract Procedures Manual: Appendix B: 2010 Table of Standard Fixture Wattages. Ver. 1.1, Southern California Edison. February 25, 2010. Web. Accessed June, 19 2010. <http://www.aesc-inc.com/download/SPC/2010SPCDocs/UnifiedManual/App%20B%20Standard%20Fixture%20Watts.pdf>
4. 2009 EPE Program Downloads. Wattage Table 2009. Web. Accessed September, 26 2009. <http://www.epelectricefficiency.com/downloads.asp?section=ci>.
5. New Jersey Clean Energy Program: Protocols to Measure Resource Savings. December 2007.
6. Thorne and Nadel, Commercial Lighting Retrofits: A Briefing Report for Program Implementers, American Council for an Energy- Efficient Economy, April 2003.

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

Lighting Power Density Reduction (New Construction)

Official Measure Code: CI-Ltg-LPD-1

Description

This measure relates to the implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction situation. Techniques like maximizing daylighting, task lighting, and efficient fixtures are used to create a system of optimal functionality while reducing total lighting power density.

Definition of Efficient Equipment

In order for this characterization to apply, this measure assumes the high efficiency equipment consists of a lighting system that exceeds the lighting power density requirements as mandated by ASHRAE 90.1-2007 Table 9.5.1 or Table 9.6.1

Definition of Baseline Equipment

The baseline efficiency assumes compliance with lighting power density requirements as mandated by ASHRAE 90.1-2007 Table 9.5.1 or Table 9.6.1

Deemed Calculation for this Measure

Annual kWh Savings = $(LPD_{base} – LPD_{ee}) / 1000 * AREA * HOURS * (1 +WHF_e)$

Summer Coincident Peak kW Savings

$$= (LPD_{base} – LPD_{ee}) / 1000 * AREA * (1 + WHF_d) * CF$$

Deemed Lifetime of Efficient Equipment

The expected measure life is measure is 15 years[397].

Deemed Measure Cost

The incremental capital costs for this measure vary by the assumed baseline and efficient equipment scenarios. Incremental costs by measure type are presented below:

Coincidence Factor

The summer peak coincidence factor for this measure is dependent on building type as below:

[397] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Building Type	CF[398]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel Guest Rooms	0.37
Hotel/Motel Common Area	0.90
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[399]
Other	0.65

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = ((LPD_{base} - LPD_{ee}) / 1000 * AREA * HOURS * (1 + WHF_e)$

Where:

LPD_{base} = allowed lighting power density (watts per square foot) based on energy code requirements for building or space type. See ASHRAE 90.1-2007 Table 9.5.1 or Table 9.6.1

LPD_{ee} = actual installed lighting wattage per square foot of the efficient lighting system for building type as determined by site-surveys or design diagrams.

1000 = conversion factor (W / kW)

AREA = area of the building in square feet; determined from site-specific information

HOURS = annual operating hours of the lighting system. Use site-specific operating hours from audit report or application if available. If site-specific data not available, assume default values dependent on building type as below:

[398] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

[399] Assumption consistent with 8,760 operating hours assumption.

Building Type	HOURS	Source
Food Sales	5,544	OH TRM[400]
Food Service	3,357	Duke OH[401] + NC[402]
Health Care	6,802	Duke OH + NC
Hotel/Motel	3,754	Duke OH + NC
Office	3,253	Duke OH
Public Assembly	2,867	Duke OH + NC
Public Services (non-food)	3,299	Duke OH
Retail	4,984	Duke OH, I&M
Warehouse	3,824	Duke OH, I&M
School	2,379	Duke OH, I&M
College	3,749	Duke OH + NC
Industrial – 1 Shift	2,857	OH TRM
Industrial – 2 Shift	4,730	OH TRM
Industrial – 3 Shift	6,631	OH TRM
Exterior	4,300	OH TRM
Other	4,408	Duke OH

WHFe = lighting-HVAC Interation Factor for energy; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

Summer Coincident Peak Demand Savings

ΔkW = $(LPD_{base} – LPD_{ee}) * AREA * CF * (1 + WHF_d) / 1000$

Where:

WHFd = lighting-HVAC waste heat factor for demand; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

CF = Summer Peak Coincidence Factor for measure

[400] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

[401] Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in Ohio, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2010.

[402] Hall, et al. Evaluation of the Non-Residential Smart Saver Prescriptive Program in North and South Carolina, Prepared for Duke Energy Inc, TecMarket Works, Oregon, WI. 2011.

Dependent on building type as below:

Building Type	CF[403]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel Guest Room	0.37
Hotel/Motel Common Area	0.90
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00
Other	0.65

Fossil Fuel Impact Descriptions and Calculation

ΔMMBtu = ΔkWh * WHFg

Where:

WHFg = lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. See Appendix B.

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Referenced Documents

[403] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

LED Case Lighting with/without Motion Sensors (New Construction; Retrofit – Early Replacement

Official Measure Code: CI-Refrig-LEDCase-1

Description

This measure relates to the installation of LED lamps with and without motion sensors in vertical display refrigerators, coolers, and freezers replacing T8 or T12 linear fluorescent lamp technology. LED lamps should be systems intended for this application. LED lamps not only provide the same light output with lower connected wattages, but also produce less waste heat which decreases the cooling load on the refrigeration system and energy needed by the refrigerator compressor. Additional savings can be achieved from the installation of a motion sensor which automatically dims the lighting system when the space is unoccupied. Retrofit projects must completely remove the existing fluorescent fixture end connectors and ballasts to qualify, though wiring may be reused. Eligible fixtures include new, replacement, and retrofit. Savings and assumptions are based on a per door basis.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be LED case lighting with or without motion sensors on refrigerators, coolers, and freezers - specifically on vertical displays.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be T8 or T12 linear fluorescent lamps.

Deemed Calculation for this Measure

Annual kWh Savings

$$= (WATTS_{base} – WATTS_{ee}) / 1000 * N_{doors} * HOURS * (1 + WHF_e) * ESF_{MC}$$

Summer Coincident Peak kW Savings

$$= (WATTS_{base} – WATTS_{ee}) / 1000 * N_{doors} * (1 + WHF_d) * CF$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 8.1 years[404].

[404] Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes annual operating hours of 6,205. <http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf>. The lifetime of the motion sensors is assumed to be equal to the lifetime of the LED lighting.

Deemed Measure Cost

The incremental capital cost for this measure is $250 per door (retrofit), and $150 (time of sale, new construction)[405].

If a motion sensor is installed, add an additional cost of $130 per 25ft of case[406].

Deemed O&M Cost Adjustments

The stream of baseline lamp replacement costs over the lifetime of the measure results in a Net Present Value[407] of $22.96. This computes to a levelized annual baseline replacement cost assumption of $4.07.

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 92%[408].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = (WATTS_{base} - WATTS_{ee}) / 1000 * N_{doors} * HOURS * (1 + WHF_e) * ESF_{MC}$$

Where:

$WATTS_{base}$ = connected wattage per door of the baseline fixtures; see table below for default values.

$WATTS_{ee}$ = connected wattage per door of the high efficiency fixtures
= Actual installed. If actual installed wattage is unknown, see table below for default values.

[405] Based on a review of TRM incremental cost assumptions from Oregon and Vermont, supplemented with completed project information from New York.
[406] "LED Case Lighting With and Without Motion Sensors" presentation, Michele Friedrich, PECI, January 2010.
[407] Using a discount rate of 5.7% (as is used for Efficiency Vermont). Assumes baseline ballast life exceeds the life of the LED assembly.
[408] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

LED Refrigerated Case Lighting System Baseline and Efficient Wattages[409]

Type of Measure	Efficient Lamp	Baseline Lamp	Efficient Fixture Wattage (WATTS ee)	Baseline Fixture Wattage (WATTS base)	Fixture Savings (Watts)
Refrigerated Case Lighting per door	5' LED Case Lighting System	5' T8 Case Lighting System	38	76	38
Refrigerated Case Lighting per door	6' LED Case Lighting System	6' T12HO Case Lighting System	46	112	66

1000 = conversion factor from watts to kilowatts

N_{doors} = number of doors
= Actual installed

HOURS = annual operating hours; assume 6,205 operating hours per year[410] if actual operating hours are unknown

ESF_{MC} = Energy Savings Factor; additional savings percentage achieved with a motion sensor. Assume a value of 1.0 if no motion sensor is installed, or 1.43 if motion sensor is installed.[411]

WHFe = waste heat factor for energy to account for cooling savings from efficient lighting. For prescriptive refrigerated lighting measures, the default value is 0.41 for refrigerated space and 0.52 for freezer space[412].

Summer Coincident Peak Demand Savings

$$\Delta kW = (WATTS_{base} - WATTS_{ee}) / 1000 * N_{doors} * (1 + WHF_d) * DSF_{MC} * CF$$

Where:

WHF_d = waste heat factor for energy to account for cooling savings from efficient lighting. For prescriptive refrigerated lighting measures, the default value is 0.41 for refrigerated space and 0.52 for freezer space[413].

409 From Pacific Gas & Electric 'LED Refrig Lighting ERCO_Talking_Points_v3.pdf.' The efficient wattage, 38 and 46 watts, are the maximum allowed watts for a 5-foot and 6-foot LED refrigerated case lighting system that meets the efficiency specifications of the Designlights Consortium.

410 Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes refrigerated case lighting typically operates 17 hours per day, 365 days per year. <http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf>

411 D. Bisbee, Sacramento Municipal Utility District, "Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems", July 2008.

412 Values adopted from Hall, N. et al, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, TecMarket Works, September 1, 2009. This factor is a candidate from future adjustment due to climatic differences between Indiana and New York.

413 Values adopted from Hall, N. et al, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, TecMarket Works, September 1, 2009. This factor is a candidate from future adjustment due to climatic differences between Indiana and New York.

DSF_{MC}	= Demand Savings Factor; additional savings percentage achieved with a motion sensor. Assume a value of 1.0 if no motion sensor is installed, or 1.43 if motion sensor is installed.[414]
CF	= Summer Peak Coincidence Factor for measure = 0.92[415] (lighting in food sales)

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The stream of baseline lamp replacement costs over the lifetime of the measure results in a Net Present Value[416] of $22.96. This computes to a levelized annual baseline replacement cost assumption of $4.07.

Baseline Lamp Cost:	$4
Baseline Lamp Life:	12,000
Baseline Lamp Labor Cost:	$5.00 (15 min @ $20 per hour labor)

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Effective date:	January 10, 2013
End date:	TBD

[414] D. Bisbee, Sacramento Municipal Utility District, "Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems", July 2008.
[415] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.
[416] Using a discount rate of 5.7% (as is used for Efficiency Vermont). Assumes baseline ballast life exceeds the life of the LED assembly.

LED Exit Signs (Retrofit)

Official Measure Code: CI-Ltg-LEDExit-1

Description

These exit signs have a string of very small, typically red or green, glowing LEDs arranged in a circle or oval. The LEDs may also be arranged in a line on the side, top or bottom of the exit sign. LED exit signs provide the best balance of safety, low maintenance, and very low energy usage compared to other exit sign technologies.

Definition of Efficient Equipment

The efficient equipment is assumed to be an exit sign illuminated by light emitting diodes.

Definition of Baseline Equipment

The baseline equipment is assumed to be a fluorescent model.

Deemed Savings for this Measure

Annual kWh Savings = 83 kWh

Summer Coincident Peak kW Savings = 0.010 kW

Deemed Lifetime of Efficient Equipment

16 years[417]

Deemed Measure Cost

$30[418]

Deemed O&M Cost Adjustments

The stream of replacement costs over the lifetime of the measure results in a Net Present Value of $59. This computes to a levelized annual baseline replacement cost assumption of $6.04.[419]

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 100%[420].

[417] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[418] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[419] This calculation assumes a replacement baseline CFL costs $4 with an estimated labor cost of $5 (assuming 20$/hour and a task time of 15 minutes). Lamp life is approximated as 2 years, assuming a 16,000 hour lamp life operating 8,760 hours per year.
[420] Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = kW_{Save} \times HOURS \times ISR \times (1+WHF_e)$$

Where:

kW_{Save} = The difference in connected load between baseline equipment and efficient equipment
= 0.009[421]

HOURS = Annual operating hours
= 8760

ISR = In service rate, the percentage of rebated units that are actually in service.
= 98%[422]

WHF_e = Waste heat factor for energy; accounts for cooling savings from efficient lighting. See Appendix B.

Summer Coincident Peak Demand Savings

$$\Delta kW = kW_{Save} \times ISR \times (1+WHF_d)$$

Where:

ISR = In service rate, the percentage of rebated units that are actually in service.
= 98%[423]

kW_{Save} = The difference in connected load between baseline equipment and efficient equipment
= 0.009[424]

WHF_d = Waste heat factor for demand to account for cooling savings from efficient lighting. See Appendix B.

Fossil Fuel Impact Descriptions and Calculation

n/a[425]

Water Impact Descriptions and Calculation

n/a

[421] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
[422] Ibid.
[423] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
[424] Efficiency Vermont TRM
[425] Pending additional information from utilities regarding the modeled waste heat factors for commercial lighting.

Deemed O&M Cost Adjustment Calculation

The stream of replacement costs over the lifetime of the measure results in a Net Present Value of $59. This computes to a levelized annual baseline replacement cost assumption of $6.04.[426]

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[426] This calculation assumes a replacement baseline CFL costs $4 with an estimated labor cost of $5 (assuming 20$/hour and a task time of 15 minutes). Lamp life is approximated as 2 years, assuming a 16,000 hour lamp life operating 8,760 hours per year.

Traffic Signals (Retrofit)

Official Measure Code: CI-Ltg-LEDTraffic-1

Description

Traffic and pedestrian signals are illuminated with light emitting diodes (LED) instead of incandescent lamps.

Definition of Efficient Equipment

Refer to the Table titled 'Traffic Signals Technology Equivalencies' for efficient technology wattage and savings assumptions.

Definition of Baseline Equipment

Refer to the Table titled 'Traffic Signals Technology Equivalencies' for baseline efficiencies and savings assumptions.

Deemed Savings for this Measure

Annual kWh Savings $= (W_{base} - W_{eff}) \times HOURS / 1000$

Summer Coincident Peak kW Savings $= (W_{base} - W_{eff}) \times CF / 1000$

Deemed Lifetime of Efficient Equipment

The assumed lifetime of an LED traffic signal is 100,000 hours (manufacturer's estimate), capped at 10 years.[427] The life in years is calculated by dividing 100,000 hrs by the annual operating hours for the particular signal type.

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments[428]

Because LEDs last much longer than incandescent bulbs, LEDs offer operation and maintenance (O&M) savings over the life of the lamps for avoided replacement lamps and the labor to install them. The following assumptions are used to calculate the O&M savings:

Incandescent bulb cost:	$3 per bulb
Labor cost to replace incandescent lamp:	$60 per signal
Life of incandescent bulb:	8000 hours

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[427] ACEEE, (1998) A Market Transformation Opportunity Assessment for LED Traffic Signals, http://www.cee1.org/gov/led/led- ace3/ace3led.pdf

[428] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

Coincidence Factor[429]

The summer peak coincidence factor (CF) for this measure is dependent on lamp type as below:

Lamp Type	CF
Red Balls, always changing or flashing	0.55
Red Arrows	0.90
Green Arrows	0.10
Green, always changing or flashing	0.43
Flashing Yellow	0.50
Yellow	0.02
“Hand” Don’t Walk Signal	0.75
“Man” Walk Signal	0.21

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = $(W_{base} - W_{eff})$ x HOURS / 1000

Where:

W_{base} = The connected load of the baseline equipment
= see Table ‘Traffic Signals Technology Equivalencies’
W_{eff} = The connected load of the efficient equipment
= see Table ‘Traffic Signals Technology Equivalencies’
EFLH = annual operating hours of the lamp
= see Table ‘Traffic Signals Technology Equivalencies’
1000 = conversion factor (W/kW)

For example, an 8 inch red, round signal:

ΔkWh = ((69 - 7) x 4818) / 1000

= 299 kWh

Summer Coincident Peak Demand Savings

ΔkW = $(W_{base} – W_{eff})$ x CF / 1000

429 Ibid

Where:

W_{base} = The connected load of the baseline equipment
= see Table 'Traffic Signals Technology Equivalencies'
W_{eff} = The connected load of the efficient equipment
= see Table 'Traffic Signals Technology Equivalencies'
CF = Summer Peak Coincidence Factor for measure

Lamp Type	CF
Red Balls, always changing or flashing	0.55
Red Arrows	0.90
Green Arrows	0.10
Green, always changing or flashing	0.43
Flashing Yellow	0.50
Yellow	0.02
"Hand" Don't Walk Signal	0.75
"Man" Walk Signal	0.21

For example, an 8 inch red, round signal:

ΔkW = ((69 – 7) x 0.55) / 1000

= 0.0341 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Reference Tables

Traffic Signals Technology Equivalencies[430]

Traffic Fixture Type	Fixture Size and Color	Efficient Lamps	Baseline Lamps	HOURS	Efficient Fixture Wattage	Baseline Fixture Wattage	Energy Savings (in kWh)	Demand Savings (kW)
Round Signals	8" Red	LED	Incandescent	4818	7	69	299	62
Round Signals	12" Red	LED	Incandescent	4818	6	150	694	144
Flashing Signal	8" Red	LED	Incandescent	4380	7	69	272	62
Flashing Signal	12" Red	LED	Incandescent	4380	6	150	631	144

[430] Technical Reference Manual for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards. Pennsylvania Public Utility Commission. May 2009

Traffic Fixture Type	Fixture Size and Color	Efficient Lamps	Baseline Lamps	HOURS	Efficient Fixture Wattage	Baseline Fixture Wattage	Energy Savings (in kWh)	Demand Savings (kW)
Flashing Signal	8" Yellow	LED	Incandescent	4380	10	69	258	59
Flashing Signal	12" Yellow	LED	Incandescent	4380	13	150	600	137
Round Signals	8" Yellow	LED	Incandescent	175	10	69	10	59
Round Signals	12" Yellow	LED	Incandescent	175	13	150	24	137
Round Signals	8" Green	LED	Incandescent	3767	9	69	266	60
Round Signals	12" Green	LED	Incandescent	3767	12	150	520	138
Turn Arrows	8" Yellow	LED	Incandescent	701	7	116	76	109
Turn Arrows	12" Yellow	LED	Incandescent	701	9	116	75	107
Turn Arrows	8" Green	LED	Incandescent	701	7	116	76	109
Turn Arrows	12" Green	LED	Incandescent	701	7	116	76	109
Pedestrian Sign	12" Hand/Man	LED	Incandescent	8760	8	116	946	108

Reference specifications for above traffic signal wattages are from the following manufacturers:

1. 8" Incandescent traffic signal bulb: General Electric Traffic Signal Model 17325-69A21/TS
2. 12" Incandescent traffic signal bulb: General Electric Signal Model 35327-150PAR46/TS
3. Incandescent Arrows & Hand/Man Pedestrian Signs: General Electric Traffic Signal Model 19010- 116A21/TS
4. 8" and 12" LED traffic signals: Leotek Models TSL-ES08 and TSL-ES12
5. 8" LED Yellow Arrow: General Electric Model DR4-YTA2-01A
6. 8" LED Green Arrow: General Electric Model DR4-GCA2-01A
7. 12" LED Yellow Arrow: Dialight Model 431-3334-001X
8. 12: LED Green Arrow: Dialight Model 432-2324-001X
9. LED Hand/Man Pedestrian Sign: Dialight 430-6450-001X

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Light Tube Commercial Skylight (Time of Sale)

Official Measure Code: CI-Ltg-LiteTube-1

Description

A tubular skylight which is 10” to 21” in diameter with a prismatic or translucent lens is installed on the roof of a commercial facility. The lens reflects light captured from the roof opening through a highly specular reflective tube down to the mounted fixture height. When in use, a light tube fixture resembles a metal halide fixture. Uses include grocery, school, retail and other single story commercial buildings.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a tubular skylight that concentrates and directs light from the roof to an area inside the facility.

Definition of Baseline Equipment

The baseline equipment for this measure is a T8 Fluorescent Lamp with comparable luminosity. The specifications for the baseline lamp depend on the size of the Light Tube being installed. See Table ‘kW/fixture Calculation Table’ in the Reference Tables section for details.

Deemed Savings for this Measure

Annual kWh Savings = NumFixtures x kW_f x 2400

Summer Coincident Peak kW Savings = NumFixtures x kW_f x 0.75

Deemed Lifetime of Efficient Equipment

The estimated useful life for a light tube commercial skylight is 10 years[431]

Deemed Measure Cost

If available, actual incremental cost should be used. For analysis purposes, assume an incremental cost for a light tube commercial skylight is $500[432]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The coincidence factor for a light tube commercial skylight is 0.75. This was determined by taking the average of several building types for the 4p-5p peak period.[433]

[431] Equal to the manufacturers standard warranty
[432] Based on a review of available manufacturer pricing information
[433] RLW Analytics. Coincidence Factor Study - Residential and Commercial Industrial Lighting Measures. Spring 2007.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = NumFixtures \times kW_f \times EFL_H$

Where:

NumFixtures = number of fixtures installed

kW_f = kilowatts saved per fixture
= See table below

EFL_H = equivalent full load hours
= 2400[434]

For example, 3 light tubes installed:

$\Delta kWh = 3 \times 0.129 \times 2400$

$= 928.8$ kWh

Summer Coincident Peak Demand Savings

$\Delta kW = NumFixtures \times kW_f \times CF$

Where:

ΔkW_f = kilowatts saved per fixture
= See table below
CF = coincidence factor
= 0.75
NumFixtures = number of fixtures being installed

For example, 3 light tubes installed:

$\Delta kW = 3 \times 0.129 \times 0.75$

$= 0.29$ kW

Fossil Fuel Impact Descriptions and Calculation

n/a

[434] 2400 hours based on replacing electric lighting with daylight 8 hr /day; 300 day/yr.

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables

kW/fixture Calculation Table:

Brand/size	Lumen Output[435]	Equivalent Fixture	kW	kWh
Solatube 21”	13,500-20,500	2-3LF32T8 172W	0.172	481.6
14”	6000-9100	1-3LF32T8	0.086	240.8
10”	3000-4600	3-18W quad	0.054	151.2
		AVERAGE	0.129	361.2

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[435] Solatube Test Report (2005). http://www.mainegreenbuilding.com/files/file/solatube/stb_lumens_datasheet.pdf

ENERGY STAR Room Air Conditioner for Commercial Use (Time of Sale)

Official Measure Code: CI-HVAC-RAC-1

Description

This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR[436] or Consortium for Energy Efficiency (CEE) Super-Efficient Home Appliances Initiative (SEHA) Tier 1[437] minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings. Applicable units are with and without louvered sides, without reverse cycle (i.e., heating), and casement.

Definition of Efficient Equipment

To qualify for this measure the new room air conditioning unit must meet either the ENERGY STAR or CEE SEHA Tier 1 efficiency standards.

Definition of Baseline Equipment

The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standard.

Deemed Calculation for this Measure

Annual kWh Savings $= (CAP) * [(1/EER_{base}) – (1/EER_{ee})] * EFLH / 1000$

Summer Coincident Peak kW Savings $= (CAP) * [(1/EER_{base}) – (1/EER_{ee})] / 1000 * 0.74$

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 12 years[438].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $80 for a CEE TIER 1 unit [439].

Deemed O&M Cost Adjustments

n/a

[436] "ENERGY STAR Program Requirements for Room Air Conditioners, Partner Commitments", U.S. Environmental Protection Agency, Accessed on 7/17/10. < http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf>
[437] "CEE Super-Efficient Home Appliances Initiative – High-Efficiency Specifications for Room Air Conditioners", Consortium for Energy Efficiency, Accessed on 7/17/10. <http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf>
[438] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[439] Based on field study conducted by Efficiency Vermont

Coincidence Factor

The coincidence factor for this measure is assumed to be 0.74 [440].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (CAP) * [(1/EER_{base}) – (1/EER_{ee})]/1000 * EFL_H

Where:

CAP = cooling capacity of the unit in Btu/h
= Actual installed

EER_{base} = Energy Efficiency Ratio of the baseline equipment; see table below for default values.

Capacity (Btu/h)	Federal Standard with louvered sides (EER)	Federal Standard without louvered sides (EER)	Federal Standard Casement-Only (EER)	Federal Standard Casement-Slider (EER)
< 8,000	>= 9.7	>=9.0	>=8.7	>=9.5
8,000 to 13,999	>= 9.8	>=8.5	>=8.7	>=9.5
14,000 to 19,999	>=9.7	>=8.5	>=8.7	>=9.5
≥ 20,000	>=8.5	>=8.5	>=8.7	>=9.5

EERee = Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed efficiency of the ENERGY STAR or CEE SEHA Tier 1 compliant unit. See table below for minimum requirements:

Capacity (Btu/h)	ENERGY STAR with louvered sides (EER)	CEE SEHA Tier 1 with louvered sides (EER)	ENERGY STAR without louvered sides (EER)	ENERGY STAR Casement-Only (EER)	ENERGY STAR Casement-Slider (EER)
< 8,000	>=10.7	>=11.2	>=9.9	>=9.6	>=10.5
8,000 to 13,999	>= 10.8	>=11.3	>=9.4	>=9.6	>=10.5
14,000 to 19,999	>=10.7	>=11.2	>=9.4	>=9.6	>=10.5
≥ 20,000	>=9.4	>=9.8	>=9.4	>=9.6	>=10.5

EFLH = cooling equivalent full load hours; see table below for default values:

[440] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

	Cooling EFLH				
Building	**Indianapolis**	**South Bend**	**Evansville**	**Ft Wayne**	**Terre Haute**
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

Summary Coincident Peak Demand Savings

$$\Delta kW = (CAP) * [(1/EER_{base}) - (1/EER_{ee})] / 1000 * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.74 [441]

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[441] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Single-Package and Split System Unitary Air Conditioners (Time of Sale, New Construction)

Official Measure Code: CI-HVAC-AC-1

Description

This measure promotes the installation of high-efficiency unitary air-, water-, and evaporatively cooled air conditioning equipment, both single-package and split systems. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure could apply to the replacing of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air-, water-, or evaporatively cooled air conditioner that exceeds the energy efficiency requirements of ASHRAE 90.1-2007.

Definition of Baseline Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a standard-efficiency air-, water, or evaporatively cooled air conditioner that meets the energy efficiency requirements of ASHRAE 90.1-2007. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Deemed Calculation for this Measure

For units with cooling capacities less than 65 kBtu/h:

Annual kWh Savings $= (kBtu/h) * [(1/SEER_{base}) – (1/SEER_{ee})] / 1000 * EFLH$

Summer Coincident Peak kW Savings

$$= (kBtu/h) * [(1/EER_{base}) – (1/EER_{ee})] / 1000 * CF$$

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

Annual kWh Savings $= (kBtu/h) * [(1/EER_{base}) – (1/EER_{ee})]/1000 * EFLH$

Summer Coincident Peak kW Savings

$$= (kBtu/h) * [(1/EER_{base}) – (1/EER_{ee})]/1000 * CF$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years.[442]

[442] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

Deemed Measure Cost

The incremental capital cost for this measure is assumed to be $100 per ton.[443]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 74%[444].

REFERENCE SECTION

Calculation of Savings

Energy Savings

For units with cooling capacities less than 65 kBtu/h:

$$\Delta kWH = (kBtu/h) * [(1/SEER_{base}) - (1/SEER_{ee})]/1000 * EFLH$$

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

$$\Delta kWH = (kBtu/h) * [(1/IEER_{base}) - (1/IEER_{ee})]/1000 * EFLH$$

Where:

kBtu/h = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).

$SEER_{base}$ = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values:

Size Category	Subcategory	Baseline Condition ASHRAE 90.1-2007
<65,000 Btu/h	Split system	13.0 SEER
	Single package	13.0 SEER
≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.0 EER 11.2 IEER
≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	10.8 EER 11.0 IEER
≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	9.8 EER 9.9 IEER
≥760,000 Btu/h	Split system and single package	9.5 EER 9.6 IEER

a. As mandated by federal equipment manufacturing standards <http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr12058.pdf>

[443] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.
[444] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

$SEER_{ee}$ = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

$IEER_{base}$ = Integrated Energy Efficiency Ratio of the baseline equipment; see table above for default values.

IEERee = Integrated Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

EFLH = cooling equivalent full load hours; see table below for default values:

	Cooling EFLH				
Building	**Indianapolis**	**South Bend**	**Evansville**	**Ft Wayne**	**Terre Haute**
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

Summer Coincident Peak Demand Savings

ΔkW = (BtuH * (1/EERbase - 1/EERee))/1000 * CF

Where:

EER_{base} = Energy Efficiency Ratio of the baseline equipment; see table above for default values.

EERee = Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

For air-cooled air conditioners < 65 kBtu/h, if the actual EER is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

CF = Summer Peak Coincidence Factor for measure
= 0.74 [445]

[445] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Heat Pump Systems (Time of Sale, New Construction)

Official Measure Code: CI-HVAC-ASHP-1

Description

This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems. This measure could apply to replacing an existing unit at the end of its useful life, or installation of a new unit in a new or existing building.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air cooled, water source, ground water source, or ground source heat pump system that exceeds the energy efficiency requirements of ASHRAE 90.1-2007.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a standard-efficiency air cooled, water source, ground water source, or ground source heat pump system that meets the energy efficiency requirements of ASHRAE 90.1-2007. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Deemed Calculation for this Measure

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

Annual kWh Savings = Annual kWh Savings_{cool} + Annual kWh Savings_{heat}
Annual kWh Savings_{cool} = (kBtu/h) * [(1/SEERbase) – (1/SEERee)] * EFLH_{cool}
Annual kWh Savings_{heat} = (kBtu/h) * [(1/HSPFbase) – (1/HSPFee)] * EFLH_{heat}
Summer Coincident Peak kW Savings
= (kBtu/h) * [(1/EERbase) – (1/EERee)] *CF

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

Annual kWh Savings = Annual kWh Savings_{cool} + Annual kWh Savings_{heat}
Annual kWh Savings_{cool} = (kBtu/h_{cool}) * [(1/IEERbase) – (1/IEERee)] * EFLH_{cool}
Annual kWh Savings_{heat} = (kBtu/h_{heat})/3.412 * [(1/COPbase) – (1/COPee)] * EFLH_{heat}
Summer Coincident Peak kW Savings
= (kBtu/h_{cool}) * [(1/EERbase) – (1/EERee)] *CF

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years.[446]

[446] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

Deemed Measure Cost

For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.[447] The incremental cost for all other equipment types should be determined on a site-specific basis.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 74%[448].

REFERENCE SECTION

Calculation of Savings

Energy Savings

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

$$\Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (kBtu/h_{cool}) * [(1/SEER_{base}) - (1/SEER_{ee})] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{cool}) * [(1/HSPF_{base}) - (1/HSPF_{ee})] * EFLH_{heat}$$

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

$$\Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (kBtu/h_{cool}) * [(1/IEER_{base}) - (1/IEER_{ee})] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{heat})/3.412 * [(1/COP_{base}) - (1/COP_{ee})] * EFLH_{heat}$$

Where:

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

$SEER_{base}$ = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values.

[447] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.
[448] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Verification of this factor is pending information from the utilities.

Size Category	Subcategory	Baseline Condition (ASHRAE 90.1-2007)
<65,000 Btu/h	Split system	13.0 SEER / 7.7 HSPF
	Single package	13.0 SEER / 7.7 HSPF
≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.0 EER / 11.2 IEER / 3.3 COP
≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	10.8 EER / 11.0 IEER / 3.2 COP
≥240,000 Btu/h	Split system and single package	9.8 EER / 9.9 IEER / 3.2 COP

$SEER_{ee}$ = Seasonal Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

$EFLH_{cool}$ = cooling mode equivalent full load hours; see table below for default values:

	Cooling EFLH				
Building	**Indianapolis**	**South Bend**	**Evansville**	**Ft Wayne**	**Terre Haute**
Assembly	810	721	1,047	716	955
Auto Repair	538	484	721	431	675
Big Box Retail	1,123	1,006	1,422	1,056	1,251
Fast Food Restaurant	798	738	1,066	694	905
Full Service Restaurant	729	641	967	633	837
Grocery	1,123	1,006	1,422	1,056	1,251
Light Industrial	690	598	842	642	760
Primary School	514	456	573	454	503
Religious Worship	401	360	516	357	444
Small Office	1,096	1,015	1,299	1,035	1,151
Small Retail	1,032	906	1,294	977	1,142
Warehouse	690	598	842	642	760
Other	795	711	1,001	725	886

$HSPF_{base}$ = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

$HSPF_{ee}$ = Heating Seasonal Performance Factor of the energy efficient equipment.
= Actual installed

$EFLH_{heat}$ = heating mode equivalent full load hours; see table below for default values.

	Heating EFLH				
Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

$IEER_{base}$ = Integrated Energy Efficiency Ratio of the baseline equipment; see the table above for values.

$IEER_{ee}$ = Integrated Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

$kBtu/h_{heat}$ = capacity of the heating equipment in kBtu per hour.
= Actual installed

3.412 = Btu per Wh.

COP_{base} = coefficient of performance of the baseline equipment; see table above for values.

COP_{ee} = coefficient of performance of the energy efficient equipment.
= Actual installed

Summer Coincident Peak Demand Savings

$$\Delta kW = (kBtu/h_{cool}) * [(1/EER_{base}) – (1/EER_{ee})] *CF$$

Where:

EER_{base} = Energy Efficiency Ratio of the baseline equipment; see the table above for values.

EER_{ee} = Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

CF = Summer Peak Coincidence Factor for measure
= 0.74 [449]

[449] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Verification of these factors pending information from the utilities.

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

Outside Air Economizer with Dual-Enthalpy Sensors (Time of Sale, Retrofit – New Equipment)

Official Measure Code: CI-HVAC-Econ-1

Description

This measure is to upgrade the outside air dry-bulb economizer to a dual enthalpy controlled economizer. The new control system will continuously monitor the enthalpy of both outside air and return air. The system will control the system dampers and adjust based on the two readings.

Definition of Efficient Equipment

The efficient equipment is a dual-enthalpy economizer on the HVAC system.

Definition of Baseline Equipment

The existing condition for this measure is an outside air dry-bulb economizer.

Deemed Calculation for this Measure

Annual kWh Savings $= TONS \times \Delta kWh_{ton}$

Summer Coincident Peak kW Savings = 0

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years[450] .

Deemed Measure Cost

The incremental cost for this measure is assumed to be $400[451]

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Coincidence Factor

There are no expected summer peak kW savings for this measure, so the coincidence factor is 0.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = TONS \times \Delta kWh_{ton}$

[450] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008

[451] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

Where:

TONS	= the rated capacity of the unit controlled by the economizer. To be collected with the application.
ΔkWh_{ton}	= the kWh savings per ton, based on building and region of the state. See table below in the “Reference Table” section.

For example, an economizer on a 10 ton air conditioning unit in a big box retail building in Indianapolis:

$$\Delta kWh = 10 \times 137$$
$$= 1{,}370 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = 0$$

Baseline Adjustment

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

There are no expected fossil fuel impacts associated with this measure.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Reference Table

Dual Enthalpy Economizer Savings[452]

Building	City	kWh
Assembly	Evansville	24
	Ft. Wayne	23
	Indianapolis	22
	South Bend	21
	Terre Haute	32
Big Box Retail	Evansville	145
	Ft. Wayne	139
	Indianapolis	137
	South Bend	125
	Terre Haute	215
Fast Food Restaurant	Evansville	37
	Ft. Wayne	33
	Indianapolis	34
	South Bend	32
	Terre Haute	35
Full Service Restaurant	Evansville	18
	Ft. Wayne	18
	Indianapolis	19
	South Bend	18
	Terre Haute	31
Hospital	Indianapolis	1014
	South Bend	1033
	Evansville	1125
	Ft. Wayne	1212
	Terre Haute	1149
Hotel	Indianapolis	766
	South Bend	823
	Evansville	1444
	Ft. Wayne	1641
	Terre Haute	1563
Large Office	Evansville	999
	Ft. Wayne	980
	Indianapolis	996
	South Bend	947
	Terre Haute	1056

452 Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Building	City	kWh
Light Industrial	Evansville	38
	Ft. Wayne	34
	Indianapolis	40
	South Bend	39
	Terre Haute	40
Primary School	Evansville	50
	Ft. Wayne	50
	Indianapolis	54
	South Bend	47
	Terre Haute	84
Small Office	Evansville	173
	Ft. Wayne	192
	Indianapolis	183
	South Bend	176
	Terre Haute	186
Small Retail	Evansville	109
	Ft. Wayne	110
	Indianapolis	115
	South Bend	105
	Terre Haute	146
Warehouse	Indianapolis	40
	South Bend	39
	Evansville	38
	Ft. Wayne	34
	Terre Haute	40
Other	Indianapolis	285
	South Bend	290
	Evansville	350
	Ft. Wayne	367
	Terre Haute	380

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Demand Controlled Ventilation

Official Measure Code: CI-HVAC-DCV-1

Description

Demand controlled ventilation (DCV) systems were analyzed assuming an air-side economizer with zone-level CO_2 sensor controls were added to packaged rooftop equipment, thus the savings represent the combined effect of the DCV and the air side economizer.

Definition of Efficient Equipment

HVAC system with demand controlled ventilation systems added

Definition of Baseline Equipment

HVAC system without demand controlled ventilation

Deemed Calculation for this Measure

Annual kWh Savings = $SF / 1000 * \Delta kWh_{kSF}$

Summer Coincident Peak kW Savings = $SF / 1000 * \Delta kW_{kSF} * 0.74$

Annual MMBtu Savings = $SF / 1000 * \Delta MMBtu_{kSF}$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $115 per 1000 SF of floor area.

Deemed O&M Cost Adjustments

NA

Coincidence Factor

The summer peak coincidence factor for this measure is 0.74

REFERENCE SECTION

Calculation of Savings

$$\Delta kWh = SF / 1000 * \Delta kWh_{kSF}$$

Where:

SF = The conditioned square footage served by the system with DCV controls installed.

ΔkWh_{kSF} = the kWh savings per thousand square feet of conditioned floor area. This depends on the building type and region in Indiana, and can be found in the lookup table below.

For example, DCV controls applied to an HVAC system serving a 2000 SF small retail store in Indianapolis:

ΔkWh = SF / 1000 * ΔkWh_{kSF}

= 2000 / 1000 * 668
= 1,336 kWh

Summer Coincident Peak Demand Savings

ΔkW = SF / 1000 * ΔkW_{kSF} * CF

Where:

ΔkW_{kSF} = the kW savings per thousand square feet of conditioned floor area. This depends on the building type and region in Indiana, and can be found in the lookup table below.
CF = The summer coincident peak factor, or 0.74.

For example, DCV controls applied to an HVAC system serving a 2000 SF small retail store in Indianapolis:

ΔkW = SF / 1000 * ΔkW_{kSF}

= 2000 / 1000 * 0.109
= 0.22 kW

Baseline Adjustment
There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu$ = SF / 1000 * $\Delta MMBtu_{kSF}$

Where:

$\Delta MMBtu_{kSF}$ = unit gas savings per thousand square feet of conditioned floor space. See lookup table below.

For example, DCV controls applied to an HVAC system serving a 2000 SF small retail store in Indianapolis:

$\Delta MMBtu$ = SF / 1000 * $\Delta MMBtu_{kSF}$
= 2000 / 1000 * 29.7
= 59.4 MMBtu

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Reference Tables

Building	City	kWh	kW	MMBtu
Assembly	Evansville	747	0.394	78.2
	Ft. Wayne	536	0.129	98.0
	Indianapolis	599	0.138	97.4
	South Bend	629	0.224	100.1
	Terre Haute	614	0.181	98.8
Big Box Retail	Evansville	742	0.314	9.8
	Ft. Wayne	547	0.212	15.6
	Indianapolis	578	0.383	16.1
	South Bend	676	0.505	16.1
	Terre Haute	627	0.444	16.1
Fast Food Restaurant	Evansville	1,817	0.588	84.0
	Ft. Wayne	1,193	0.588	122.7
	Indianapolis	1,408	0.588	125.2
	South Bend	1,428	0.850	129.0
	Terre Haute	1,418	0.325	127.1
Full Service Restaurant	Evansville	1,046	0.325	62.7
	Ft. Wayne	739	0.325	91.9
	Indianapolis	836	0.175	93.3
	South Bend	874	0.475	97.0
	Terre Haute	855	0.325	95.2
Light Industrial	Evansville	129	0.040	7.6
	Ft. Wayne	105	0.032	11.5
	Indianapolis	124	0.033	11.8
	South Bend	101	0.069	12.0
	Terre Haute	113	0.051	11.9
Primary School	Evansville	668	1.122	39.5
	Ft. Wayne	412	0.616	56.1
	Indianapolis	496	1.322	55.9
	South Bend	519	1.986	58.9
	Terre Haute	508	1.654	57.4
Small Office	Evansville	732	0.000	5.9
	Ft. Wayne	644	0.000	8.9
	Indianapolis	658	0.000	9.2
	South Bend	670	0.000	9.6
	Terre Haute	664	0.000	9.4
Small Retail	Evansville	827	0.156	18.3
	Ft. Wayne	633	0.078	28.8
	Indianapolis	668	0.109	29.7
	South Bend	737	0.422	31.6
	Terre Haute	703	0.266	30.7

Building	City	kWh	kW	MMBtu
Warehouse	Evansville	11	0.003	0.6
	Ft. Wayne	14	0.004	1.5
	Indianapolis	20	0.005	1.9
	South Bend	24	0.016	2.9
	Terre Haute	22	0.010	2.3

Chilled Water Reset Controls (Retrofit – New Equipment)

Official Measure Code: CI-HVAC-CHWReset-1

Description

This section covers installation of chilled water reset controls in large commercial buildings with built-up HVAC systems. Reset controls allow the chillers to operate at a higher chilled water temperature during periods of low cooling loads. The baseline condition is assumed to be constant chilled water temperature of 45°F. The reset strategies use a 5°F reset[453]. Energy savings are realized through improved chiller efficiency. Data for both air- cooled and water-cooled chillers are shown. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per ton of chiller capacity controlled.

Definition of Efficient Equipment

The efficient condition is a chilled water reset, with the maximum chilled water temperature of 50°F.

Definition of Baseline Equipment

The baseline condition is a fixed chilled water temperature of 45°F.

Deemed Calculation for this Measure

Annual kWh Savings = TONS x ΔkWh_{ton}

Summer Coincident Peak kW Savings = TONS x ΔkW_{ton}

Annual MMBTU Savings = TONS x $\Delta MMBtu_{ton}$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years[454] .

Deemed Measure Cost

The full installed cost for this measure is $681.34 per control[455].

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 74%[456].

[453] ASHRAE 90.1 2007 requires chilled and hot water temperature reset for systems with a capacity greater than 300,000 BTU/h. To avoid incenting code, this characterization should apply to smaller systems and retrofits only.

[454] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008

[455] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = TONS \times \Delta kWh_{ton}$

Where:

TONS = the rated capacity of the unit controlled by the reset controller. To be collected with the application.

ΔkWh_{ton} = the kWh savings per ton, this depends on whether the chiller is air-cooled or water- cooled. See table below.

For example, chilled water reset on a 10-ton constant volume air-cooled chiller in Indianapolis:

$\Delta kWh = 10 \times 102$
$= 1020$ kWh

Summer Coincident Peak Demand Savings

$\Delta kW = TONS \times \Delta kW_{ton} \times CF$

Where:

ΔkW_{ton} = the kW savings per ton, this depends on whether the chiller is air-cooled or water-cooled. See table below.

CF = The summer coincident peak factor, or 0.74.

For example, chilled water reset on a 10-ton constant volume air-cooled chiller in Indianapolis:

$\Delta kW = 10 \times 0.023 \times 0.74$
$= 0.17$ kW

Baseline Adjustment

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = TONS \times \Delta MMBtu_{ton}$

Where:

$\Delta MMBtu_{ton}$ = the gas savings per ton, See table below.

[456] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Verification of this factor is pending information from the utilities.

For example, chilled water reset on a 10-ton constant volume chiller in Indianapolis:

$$\Delta MMBtu = 10 \times 0.12$$
$$= 1.2 \text{ MMBtu}$$

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Reference Tables

Table 11. Chilled water reset controls[457]

Hospital

System	City	kWh	kW	MMBtu
CV reheat econ	Evansville	332	0.052	0.25
	Indianapolis	308	0.036	0.30
	South Bend	287	0.001	0.29
	Ft. Wayne	309	0.037	0.49
	Terre Haute	316	0.034	0.43
CV reheat no econ	Evansville	237	0.035	0.17
	Ft. Wayne	245	0.024	0.25
	Indianapolis	223	0.024	0.19
	South Bend	211	0.001	0.18
	Terre Haute	240	0.023	0.22
VAV reheat econ	Evansville	120	0.001	0.13
	Indianapolis	123	0.011	0.25
	South Bend	122	0.007	0.29
	Ft. Wayne	152	0.019	0.26
	Terre Haute	154	0.083	0.16

Hotel

System	City	kWh	kW	MMBtu
CV reheat econ	Indianapolis	121	0.016	0.01
	South Bend	114	0.016	0.01
	Evansville	147	0.016	-0.02
	Ft. Wayne	155	0.014	-0.01
	Terre Haute	139	0.020	-0.01
CV reheat no econ	Evansville	155	0.016	-0.01
	Ft. Wayne	160	0.014	0.01
	Indianapolis	56	0.015	0.00
	South Bend	51	0.017	0.00
	Terre Haute	153	0.020	0.00
VAV reheat econ	Indianapolis	125	0.016	0.00
	South Bend	121	0.016	0.00
	Evansville	173	0.018	0.02
	Ft. Wayne	177	0.014	0.05
	Terre Haute	168	0.020	0.02

[457] Unit energy, demand, and gas savings data is based on a series of prototypical commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Large Office

System	City	kWh	kW	MMBtu
CV reheat econ with Water Cooled Chiller	Evansville	125	0.011	0.24
	Ft. Wayne	130	0.016	0.26
	Indianapolis	122	0.011	0.19
	South Bend	125	0.010	0.25
	Terre Haute	112	0.007	0.19
CV reheat no econ with Water Cooled Chiller	Evansville	168	0.024	0.16
	Ft. Wayne	162	0.017	0.15
	Indianapolis	164	0.019	0.13
	South Bend	154	0.014	0.16
	Terre Haute	171	0.009	0.10
VAV reheat econ with Water Cooled Chiller	Evansville	104	0.026	0.11
	Ft. Wayne	112	0.013	0.14
	Indianapolis	102	0.023	0.12
	South Bend	104	0.008	0.10
	Terre Haute	103	0.023	0.10

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End date: TBD

Variable Frequency Drives for HVAC Applications (Time of Sale, Retrofit – New Equipment)

Official Measure Code: CI-HVAC-VFD-1

Description

A variable frequency drive installed on an HVAC system pump or fan motor. The VFD will modulate the speed of the motor when it is not needed to run at full load. Since the power of the motor is proportional to the cube of the speed, this will result in significant energy savings.

Definition of Efficient Equipment

The efficient condition is a variable frequency drive on an HVAC system pump or fan motor.

Definition of Baseline Equipment

For VFDs on fans, the baseline is a variable volume fan with variable inlet vanes. For VFDs on pumps, the baseline is a constant volume motor.

Deemed Calculation for this Measure

Annual Energy Savings Algorithm

$$\Delta kWh = hp * SF_{kWh}$$

Summer Coincident Peak kW Savings Algorithm

$$\Delta kW = hp * SF_{kW}$$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years.[458]

Deemed Measure Cost

See table below[459]

HP	Total Installed Cost
5	$1,330
7.5	$1,622
10	$1,898
15	$2,518
20	$3,059

[458] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008
[459] Equipment Costs from Granger 2008 Catalog pp. 286-289, average across available voltages and models. Labor costs from RSMeans Mechanical Cost Data, 2008. Used average cost adjustment for all cities listed in Indiana.

Deemed O&M Cost Adjustments

There are no expected O&M savings associated with this measure.

Coincidence Factor

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

REFERENCE SECTION

Calculation of Savings

Annual Energy Savings Algorithm

$\Delta kWh = hp * SF_{kWh}$

Where:

hp = nameplate hp of motor controlled by VFD

SF_{kWh} = kWh savings factor for the installation of VFD [kWh/hp],
= See “kWh Savings Factors” table in “Reference Tables” section below

Summer Coincident Peak kW Savings Algorithm

$\Delta kW = hp * SF_{kW}$

Where:

SF_{kW} = kW savings factor for the installation VFD [kWh/hp],

= See “kW Savings Factors” table in “Reference Tables”section below.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M savings associated with this measure.

Reference Tables

Hospital

Measure	City	System	kWh/unit	Summer kW/unit
VFD Return Fan	Indianapolis	VAV reheat econ	1,836	0.250
	South Bend		1,758	0.221
	Evansville		1,907	0.257
	Fort Wayne		1,774	0.238
	Terre Haute		1,857	0.244
VFD Supply Fan	Indianapolis		2,069	0.306
	South Bend		1,994	0.269
	Evansville		2,205	0.309
	Fort Wayne		1,982	0.572
	Terre Haute		2,184	0.297
VFD Tower Fan	Indianapolis	CV reheat no econ	933	0.000
		CV reheat econ	784	0.000
		VAV reheat econ	477	0.000
	South Bend	CV reheat no econ	861	0.000
		CV reheat econ	711	0.000
		VAV reheat econ	452	0.000
	Evansville	CV reheat no econ	1,091	0.000
		CV reheat econ	937	0.000
		VAV reheat econ	538	0.000
	Fort Wayne	CV reheat no econ	846	0.000
		CV reheat econ	713	0.000
		VAV reheat econ	421	0.000
	Terre Haute	CV reheat no econ	1,003	0.000
		CV reheat econ	848	0.000
		VAV reheat econ	545	0.000

Measure	City	System	kWh/unit	Summer kW/unit
VFD CHW Pump	Indianapolis	CV reheat no econ	6,655	0.735
		CV reheat econ	6,814	0.735
		VAV reheat econ	6,685	0.709
	South Bend	CV reheat no econ	6,722	0.511
		CV reheat econ	6,814	0.511
		VAV reheat econ	6,718	0.689
	Evansville	CV reheat no econ	6,639	0.763
		CV reheat econ	6,833	0.763
		VAV reheat econ	6,669	0.723
	Fort Wayne	CV reheat no econ	6,671	0.719
		CV reheat econ	6,789	0.719
		VAV reheat econ	6,689	1.314
	Terre Haute	CV reheat no econ	6,586	0.696
		CV reheat econ	6,747	0.697
		VAV reheat econ	6,645	0.697
VFD HW Pump	Indianapolis	CV reheat no econ	6,146	0.766
		CV reheat econ	5,665	0.766
		VAV reheat econ	5,142	0.829
	South Bend	CV reheat no econ	6,242	0.622
		CV reheat econ	5,738	0.622
		VAV reheat econ	5,375	0.826
	Evansville	CV reheat no econ	6,057	0.761
		CV reheat econ	5,622	0.761
		VAV reheat econ	5,409	0.852
	Fort Wayne	CV reheat no econ	6,226	0.764
		CV reheat econ	5,720	0.764
		VAV reheat econ	5,369	0.820
	Terre Haute	CV reheat no econ	6,091	0.779
		CV reheat econ	5,647	0.779
		VAV reheat econ	5,211	0.851
VFD CW Pump	Indianapolis	CV reheat no econ	1,989	0.097
		CV reheat econ	1,995	0.097
		VAV reheat econ	2,083	0.097
	South Bend	CV reheat no econ	1,979	0.095
		CV reheat econ	1,985	0.095
		VAV reheat econ	2,069	0.097
	Evansville	CV reheat no econ	2,005	0.097
		CV reheat econ	2,011	0.097
		VAV reheat econ	2,085	0.234
	Fort Wayne	CV reheat no econ	2,007	0.095
		CV reheat econ	2,010	0.095
		VAV reheat econ	2,082	0.234
	Terre Haute	CV reheat no econ	1,953	0.096
		CV reheat econ	1,956	0.096
		VAV reheat econ	2,078	0.096

Hotel

Measure	City	System	kWh/unit	Summer kW/unit
VFD Return Fan	Indianapolis	VAV reheat econ	276	0.133
	South Bend		276	0.117
	Evansville		150	0.000
	Fort Wayne		243	0.126
	Terre Haute		200	0.065
VFD Supply Fan	Indianapolis		163	0.126
	South Bend		164	0.121
	Evansville		59	0.004
	Fort Wayne		127	0.124
	Terre Haute		95	0.052
VFD Tower Fan	Indianapolis	CV reheat no econ	1,416	0.000
		CV reheat econ	1,124	0.000
		VAV reheat econ	832	0.000
	South Bend	CV reheat no econ	1,536	0.000
		CV reheat econ	1,193	0.000
		VAV reheat econ	850	0.000
	Evansville	CV reheat no econ	1,428	0.000
		CV reheat econ	1,176	0.000
		VAV reheat econ	924	0.000
	Fort Wayne	CV reheat no econ	1,378	0.000
		CV reheat econ	1,103	0.000
		VAV reheat econ	828	0.000
	Terre Haute	CV reheat no econ	1,349	0.000
		CV reheat econ	1,076	0.000
		VAV reheat econ	804	0.000

Measure	City	System	kWh/unit	Summer kW/unit
VFD CHW Pump	Indianapolis	CV reheat no econ	6,657	0.639
		CV reheat econ	6,938	0.639
		VAV reheat econ	6,977	0.609
	South Bend	CV reheat no econ	6,709	0.646
		CV reheat econ	7,021	0.646
		VAV reheat econ	7,109	0.612
	Evansville	CV reheat no econ	6,596	0.597
		CV reheat econ	6,857	0.597
		VAV reheat econ	6,874	0.597
	Fort Wayne	CV reheat no econ	6,760	0.606
		CV reheat econ	7,014	0.606
		VAV reheat econ	7,085	0.606
	Terre Haute	CV reheat no econ	6,643	0.594
		CV reheat econ	6,898	0.594
		VAV reheat econ	6,945	0.621
VFD HW Pump	Indianapolis	CV reheat no econ	7,903	0.704
		CV reheat econ	6,557	0.704
		VAV reheat econ	6,574	0.704
	South Bend	CV reheat no econ	7,978	0.704
		CV reheat econ	6,521	0.704
		VAV reheat econ	6,540	0.704
	Evansville	CV reheat no econ	8,086	0.704
		CV reheat econ	6,681	0.704
		VAV reheat econ	6,720	0.704
	Fort Wayne	CV reheat no econ	8,117	0.704
		CV reheat econ	6,592	0.704
		VAV reheat econ	6,621	0.704
	Terre Haute	CV reheat no econ	8,037	0.704
		CV reheat econ	6,607	0.704
		VAV reheat econ	6,610	0.704
VFD CW Pump	Indianapolis	CV reheat no econ	77	0.000
		CV reheat econ	72	0.000
		VAV reheat econ	67	0.000
	South Bend	CV reheat no econ	82	0.000
		CV reheat econ	75	0.000
		VAV reheat econ	67	0.000
	Evansville	CV reheat no econ	79	0.000
		CV reheat econ	73	0.000
		VAV reheat econ	67	0.000
	Fort Wayne	CV reheat no econ	79	0.000
		CV reheat econ	72	0.000
		VAV reheat econ	64	0.000
	Terre Haute	CV reheat no econ	78	0.000
		CV reheat econ	72	0.000
		VAV reheat econ	67	0.000

Large Office

Measure	City	System	kWh/unit	Summer kW/unit
VFD Return Fan	Indianapolis	VAV reheat econ	1,406	0.287
	South Bend		1,339	0.189
	Evansville		1,387	0.239
	Fort Wayne		1,384	0.225
	Terre Haute		1,415	0.287
VFD Supply Fan	Indianapolis		1,771	0.356
	South Bend		1,689	0.234
	Evansville		1,782	0.297
	Fort Wayne		1,771	0.350
	Terre Haute		1,790	0.356
VFD Tower Fan	Indianapolis	CV reheat no econ	49	0.000
		CV reheat econ	71	0.000
		VAV reheat econ	10	0.000
	South Bend	CV reheat no econ	39	0.000
		CV reheat econ	59	0.000
		VAV reheat econ	28	0.000
	Evansville	CV reheat no econ	63	0.000
		CV reheat econ	77	0.000
		VAV reheat econ	45	0.000
	Fort Wayne	CV reheat no econ	23	0.000
		CV reheat econ	38	0.000
		VAV reheat econ	11	0.000
	Terre Haute	CV reheat no econ	84	0.000
		CV reheat econ	107	0.000
		VAV reheat econ	35	0.000

Measure	City	System	kWh/unit	Summer kW/unit
VFD CHW Pump	Indianapolis	CV reheat no econ	3,865	0.474
		CV reheat econ	4,099	0.476
		VAV reheat econ	4,016	0.432
	South Bend	CV reheat no econ	3,947	0.417
		CV reheat econ	4,249	0.417
		VAV reheat econ	4,101	0.159
	Evansville	CV reheat no econ	3,913	0.595
		CV reheat econ	4,064	0.587
		VAV reheat econ	3,701	0.390
	Fort Wayne	CV reheat no econ	4,114	0.441
		CV reheat econ	4,354	0.441
		VAV reheat econ	4,242	0.140
	Terre Haute	CV reheat no econ	3,603	0.423
		CV reheat econ	3,778	0.423
		VAV reheat econ	3,783	0.483
VFD HW Pump	Indianapolis	CV reheat no econ	3,933	1.001
		CV reheat econ	3,470	1.001
		VAV reheat econ	4,010	0.903
	South Bend	CV reheat no econ	3,557	0.887
		CV reheat econ	3,122	0.882
		VAV reheat econ	4,139	0.877
	Evansville	CV reheat no econ	3,637	0.833
		CV reheat econ	3,349	0.852
		VAV reheat econ	4,431	0.979
	Fort Wayne	CV reheat no econ	3,699	0.962
		CV reheat econ	3,183	0.971
		VAV reheat econ	4,038	2.035
	Terre Haute	CV reheat no econ	4,391	1.039
		CV reheat econ	3,840	1.035
		VAV reheat econ	4,206	0.961
VFD CW Pump	Indianapolis	CV reheat no econ	951	0.100
		CV reheat econ	1,123	0.100
		VAV reheat econ	1,328	0.100
	South Bend	CV reheat no econ	1,047	0.102
		CV reheat econ	1,165	0.100
		VAV reheat econ	1,298	0.100
	Evansville	CV reheat no econ	908	0.102
		CV reheat econ	1,028	0.100
		VAV reheat econ	1,206	0.102
	Fort Wayne	CV reheat no econ	1,079	0.101
		CV reheat econ	1,200	0.101
		VAV reheat econ	1,367	0.100
	Terre Haute	CV reheat no econ	826	0.101
		CV reheat econ	1,038	0.100
		VAV reheat econ	1,258	0.101

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

High Efficiency Pumps

Official Measure Code: CI-Proc-Pump-1

Description

This section covers pump efficiency improvements in commercial and industrial applications.

Definition of Efficient Equipment

Efficient pump and motor combination, with EISA compliant motor.

Definition of Baseline Equipment

Standard efficiency pump and motor combination

Deemed Calculation for this Measure

Deemed values for Annual kWh and Summer Coincident Peak kW Savings as a function of pump motor size are shown below:

Motor Size (hp)	kWh savings per year	kW savings
1.5	617	0.13
2	900	0.19
3	1,841	0.39
5	3,528	0.75
7.5	5,438	1.15
10	5,952	1.26
15	7,848	1.66
20	7,246	1.54

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 yr.

Deemed Measure Cost

The incremental cost for this measure is shown below:

Motor Size (hp)	Incremental Cost (per hp)
1.5	$233.33
2	$175.00
3	$116.67
5	$68.20
7.5	$66.40
10	$33.20
15	$39.00
20	$42.50

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

The summer peak coincidence factor for this measure is 0.78

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = HP * 0.746 * (1 / (\eta Motor_{Base} * \eta Pump_{Base}) - 1 /(\eta Motor_{Eff} * \eta Pump_{Eff})) * LF * Hrs/year$$

Where:

HP = Horsepower of motor
$\eta Pump_{Base}$ = Baseline pump efficiency
$\eta Pump_{Eff}$ = Efficient pump efficiency
$\eta Motor_{Base}$ = Baseline pump motor efficiency
$\eta Motor_{Eff}$ = Efficient pump motor efficiency
LF = Motor Load factor
= 0.66
Hrs/year = Assumed hours of pump operation per year
= Actual operating hours (Use 3680 default value if not known)

Pump and motor efficiency are a function of the motor size. Default values are shown below:

Motor Size (hp)	$\eta Pump_{Base}$	$\eta Pump_{Eff}$	$\eta Motor_{Base}$	$\eta Motor_{Eff}$
1.5	0.60	0.63	0.80	0.855
2	0.60	0.63	0.80	0.865
3	0.60	0.65	0.81	0.895
5	0.60	0.68	0.82	0.895
7.5	0.64	0.73	0.82	0.91
10	0.66	0.75	0.85	0.917
15	0.69	0.77	0.86	0.93
20	0.72	0.77	0.87	0.93

Note: some pump replacements may not involve motor replacement. If the existing motor is retained, then the baseline motor efficiency should be used in the calculations.

For example, kWh savings from the upgrade of a 10 hp pump and motor are calculated as follows:

$$\Delta kWh = HP * 0.746 * (1 / (\eta Motor_{Base} * \eta Pump_{Base}) - 1 /(\eta Motor_{Eff} * \eta Pump_{Eff})) * LF * Hrs/year$$
$$= 10 * 0.746 * (1/(0.66 * 0.75) – 1/(0.85 * 0.917)) * 0.66 * 3680$$
$$= 13,358 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$\Delta kW = HP * 0.746 * (1 / (\eta Motor_{Base} * \eta Pump_{Base}) - 1 /(\eta Motor_{Eff} * \eta Pump_{Eff})) * LF * CF$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.78

For example, kW savings from the upgrade of a 10 hp pump and motor are calculated as follows:

$\Delta kW = HP * 0.746 * (1 / (\eta Motor_{Base} * \eta Pump_{Base}) - 1 /(\eta Motor_{Eff} * \eta Pump_{Eff})) * LF * CF$
$= 10 * 0.746 * (1/(0.66 * 0.75) – 1/(0.85 * 0.917)) * 0.66 * 0.78$
$= 2.83$

Fossil Fuel Impact Descriptions and Calculation
N/A

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Referenced Documents:

Cool Roof (Retrofit – New Equipment)

Official Measure Code: CI-Shell-CoolRoof-1

Description

This section covers installation of "cool roof" roofing materials in commercial buildings. The cool roof is assumed to have a solar absorptance of 0.3[460] compared to a standard roof with solar absorptance of 0.8[461]. Energy and demand saving are realized through reductions in the building cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. Energy and demand impacts are normalized per thousand square feet of roof space.

Definition of Efficient Equipment

The efficient condition is a roof with a solar absorptance of 0.30.

Definition of Baseline Equipment

The baseline condition is a roof with a solar absorptance of 0.80

Deemed Calculation for this Measure

Annual kWh Savings $= SF / 1000 * \Delta kWh_{kSF}$

Summer Coincident Peak kW Savings $= SF / 1000 * \Delta kW_{kSF} \times 0.74$

Annual MMBtu Increase $= SF / 1000 * \Delta MMBtu_{kSF}$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 15 years[462].

Deemed Measure Cost

The full installed cost for retrofit applications is $8,454.67 per one thousand square feet (kSF)[463].

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Coincidence Factor

The coincidence factor is 0.74[464].

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460 Maximum value to meet Cool Roof standards under California's Title 24
461 Itron. 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study. December 2005.
462 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
463 2005 Database for Energy-Efficiency Resources (DEER), Version 2005.2.01, "Technology and Measure Cost Data", California Public Utilities Commission, October 26, 2005
464 Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = SF / 1000 * \Delta kWh_{kSF}$

Where:

SF = The square footage of the roof. To be collected with the incentive form.
ΔkWh_{kSF} = unit energy savings per 100 square feet of roof. See lookup table below.

For example, an assembly building in Indianapolis with 1,000 square feet of roof:

$\Delta kWh = 1{,}000 / 1{,}000 * 197$
$= 197\ kWh$

Summer Coincident Peak Demand Savings

$\Delta kW = SF / 1000 * \Delta kW_{kSF} \times CF$ Where:
ΔkW_{kSF} = unit demand savings per 1,000 square foot of roof area. This can be found in the table below.
CF = The summer coincident peak factor, or 0.74.

For example, an assembly building in Indianapolis with 1,000 square feet of roof:

$\Delta kW = 1{,}000 / 1{,}000 * 0.141 * 0.74$
$= 0.104\ kW$

Baseline Adjustment
There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = SF / 1000 * \Delta MMBtu_{kSF}$

Where:

$\Delta MMBtu_{kSF}$ = unit gas savings per 1000 square feet of roof space. See lookup table below.

For example, an assembly building in Indianapolis with 1,000 square feet of roof:

$\Delta MMBtu = 1{,}000 / 1{,}000 * -1.45$
$= -1.45\ MMBtu$

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Reference Tables

Building	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
Assembly	Evansville	263	0.159	-1.44
	Ft. Wayne	154	0.091	-1.63
	Indianapolis	197	0.141	-1.45
	South Bend	157	0.003	-1.41
	Terre Haute	203	0.156	-1.44
Big Box Retail	Evansville	223	0.126	-0.90
	Ft. Wayne	152	0.080	-1.16
	Indianapolis	183	0.125	-1.09
	South Bend	155	0.078	-1.02
	Terre Haute	215	0.122	-1.02
Fast Food Restaurant	Evansville	253	0.050	-1.90
	Ft. Wayne	140	0.050	-2.10
	Indianapolis	189	0.050	-2.05
	South Bend	146	0.000	-2.05
	Terre Haute	170	0.003	-2.05
Full Service Restaurant	Evansville	233	0.150	-1.55
	Ft. Wayne	152	0.100	-1.80
	Indianapolis	187	0.150	-1.78
	South Bend	152	0.050	-1.83
	Terre Haute	184	0.100	-1.43
Light Industrial	Evansville	197	0.094	-1.57
	Ft. Wayne	104	0.081	-1.63
	Indianapolis	137	0.063	-1.70
	South Bend	108	0.045	-1.66
	Terre Haute	162	0.064	-1.34
Primary School	Evansville	404	0.678	-2.86
	Ft. Wayne	241	0.506	-2.97
	Indianapolis	328	0.698	-3.01
	South Bend	240	0.636	-2.88
	Terre Haute	359	0.492	-2.34
Small Office	Evansville	230	0.060	-0.84
	Ft. Wayne	156	0.020	-1.02
	Indianapolis	187	0.020	-0.98
	South Bend	157	0.060	-0.98
	Terre Haute	189	0.080	-0.90
Small Retail	Evansville	260	0.125	-1.36
	Ft. Wayne	172	0.078	-1.61

Building	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
	Indianapolis	210	0.125	-1.58
	South Bend	170	0.031	-1.64
	Terre Haute	245	0.094	-1.16
Warehouse	Evansville	688	0.794	-4.88
	Ft. Wayne	104	0.081	-1.63
	Indianapolis	546	0.594	-5.13
	South Bend	471	0.025	-4.49
	Terre Haute	162	0.064	-1.34

Hospital

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
CV reheat econ with Air Cooled Chiller	Evansville	124	0.104	-1.57
	Indianapolis	104	0.158	-1.37
	South Bend	89	0.001	-1.19
	Ft. Wayne	107	0.085	-0.75
	Terre Haute	116	0.162	-0.71
CV reheat econ with Water Cooled Chiller	Evansville	86	0.046	-1.57
	Indianapolis	78	0.042	-1.38
	South Bend	67	0.001	-1.19
	Ft. Wayne	81	0.047	-0.75
	Terre Haute	74	0.049	-0.71
CV reheat no econ with Air Cooled Chiller	Evansville	188	0.104	-1.76
	Indianapolis	167	0.158	-1.56
	South Bend	145	0.001	-1.39
	Ft. Wayne	167	0.085	-0.85
	Terre Haute	166	0.162	-0.81
CV reheat no econ with Water Cooled Chiller	Evansville	130	0.046	-1.76
	Ft. Wayne	123	0.047	-0.85
	Indianapolis	123	0.046	-1.54
	South Bend	108	0.001	-1.36
	Terre Haute	111	0.049	-0.81
VAV reheat econ with Air Cooled Chiller	Evansville	200	0.163	-0.66
	Indianapolis	174	0.176	-0.55
	South Bend	146	0.270	-0.95
	Ft. Wayne	152	0.077	-0.80
	Terre Haute	183	0.192	-0.24
VAV reheat econ with Water Cooled Chiller	Evansville	151	0.097	-0.66
	Indianapolis	121	0.059	-0.57
	South Bend	106	0.020	-0.90
	Ft. Wayne	120	0.071	-0.83
	Terre Haute	139	0.047	-0.24

Hotel

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
CV reheat econ with Air Cooled Chiller	Indianapolis	528	0.177	-0.10
	South Bend	563	0.151	-0.09
	Evansville	771	0.135	-0.16
	Ft. Wayne	453	0.109	-0.17
	Terre Haute	544	0.198	-0.15
CV reheat econ with Water Cooled Chiller	Indianapolis	526	0.177	-0.10
	South Bend	561	0.151	-0.09
	Evansville	772	0.135	-0.16
	Ft. Wayne	453	0.114	-0.17
	Terre Haute	545	0.198	-0.15
CV reheat no econ with Air Cooled Chiller	Indianapolis	537	0.177	-0.07
	South Bend	574	0.151	-0.07
	Evansville	782	0.135	-0.15
	Ft. Wayne	464	0.109	-0.17
	Terre Haute	556	0.198	-0.14
CV reheat no econ with Water Cooled Chiller	Evansville	781	0.135	-0.15
	Ft. Wayne	464	0.114	-0.16
	Indianapolis	531	0.177	-0.07
	South Bend	570	0.151	-0.07
	Terre Haute	556	0.198	-0.14
VAV reheat econ with Air Cooled Chiller	Indianapolis	535	0.177	-0.06
	South Bend	569	0.151	-0.05
	Evansville	789	0.135	-0.07
	Ft. Wayne	470	0.114	-0.10
	Terre Haute	559	0.203	-0.07
VAV reheat econ with Water Cooled Chiller	Indianapolis	533	0.177	-0.06
	South Bend	567	0.146	-0.05
	Evansville	787	0.135	-0.07
	Ft. Wayne	467	0.114	-0.10
	Terre Haute	557	0.203	-0.07

Large Office

HVAC System	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
CV reheat econ with Air Cooled Chiller	Evansville	149	0.120	-1.63
	Ft. Wayne	95	0.000	-1.99
	Indianapolis	153	0.000	-2.06
	South Bend	120	0.143	-2.59
	Terre Haute	136	0.103	-1.40
CV reheat econ with Water Cooled Chiller	Evansville	101	0.000	-1.64
	Ft. Wayne	57	0.000	-1.99
	Indianapolis	120	0.000	-2.20
	South Bend	110	0.000	-2.61
	Terre Haute	95	0.000	-1.43
CV reheat no econ with Air Cooled Chiller	Evansville	249	0.109	-1.47
	Ft. Wayne	167	0.103	-1.93
	Indianapolis	250	0.057	-1.77
	South Bend	188	0.149	-1.85
	Terre Haute	266	0.103	-1.56
CV reheat no econ with Water Cooled Chiller	Evansville	184	0.051	-1.46
	Ft. Wayne	143	0.046	-1.93
	Indianapolis	205	0.034	-1.78
	South Bend	152	0.086	-1.85
	Terre Haute	153	0.034	-1.56
VAV reheat econ with Air Cooled Chiller	Evansville	297	0.154	-0.27
	Ft. Wayne	190	0.120	-0.87
	Indianapolis	405	0.006	0.58
	South Bend	347	0.126	-0.01
	Terre Haute	422	0.291	0.37
VAV reheat econ with Water Cooled Chiller	Evansville	220	0.029	-0.27
	Ft. Wayne	183	0.023	-0.74
	Indianapolis	350	0.000	0.58
	South Bend	252	0.069	-0.18
	Terre Haute	334	0.017	0.37

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Commercial Window Film (Retrofit – New Equipment)

Official Measure Code: CI-Shell-WinFilm-1

Description

This section covers installation of reflective window film in commercial buildings. The baseline condition is assumed to be double pane clear glass with a solar heat gain coefficient (SHGC) of 0.73 and U-value of 0.72 Btu/hr- SF-deg F. The window film is assumed to provide a SHGC of 0.40 or less. Energy and demand savings are realized through reductions in the building cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California Database for Energy Efficiency Resources (DEER), with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per 100 square feet of window.

Definition of Efficient Equipment

The efficient condition is double pane clear glass windows with a standard window film. The standard window film will lower the SHGC to 0.40.

Definition of Baseline Equipment

The baseline condition is double pane clear glass windows without any window film, with a U-value of 0.72, and a SHGC of 0.73.

Deemed Calculation for this Measure

Annual kWh Savings $= SF / 100 * \Delta kWh_{100SF}$

Summer Coincident Peak kW Savings $= SF / 100 * \Delta kW_{100SF} * 0.74$

Annual MMBtu Increase $= SF / 100 * \Delta MMBtu_{100SF}$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 years[465].

Deemed Measure Cost

This is a retrofit only measure. Actual installed cost should be use, but for analysis purposes, the full installed cost including labor is assumed as $267 per 100 square feet of window[466] .

[465] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
[466] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008

Deemed O&M Cost Adjustments

There are no expected O&M savings associated with this measure

Coincidence Factor

The summer peak coincidence factor for this measure is 74%[467].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = SF / 100 * \Delta kWh_{100SF}$

Where:

SF	= glazing surface area of installed window film, not including frame (square feet)
ΔkWh_{100SF}	= unit energy savings per 100 square feet of window film. See lookup table below.

Summer Coincident Peak Demand Savings

$\Delta kW = SF / 100 * \Delta kW_{100SF} * CF$

Where:

ΔkW_{100SF}	= unit demand savings per 100 square feet of window film. See lookup table below.
CF	= summer coincident peak factor = 0.74

Baseline Adjustment

Since this is a retrofit measure that only applies to existing buildings with clear, double pane windows, future code adjustments should not affect projected savings.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = SF / 100 * \Delta MMBtu_{100SF}$

Where:

$\Delta MMBtu_{100SF}$	= unit heating energy savings per 100 square feet of window film. See lookup table above.

[467] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M savings or costs associated with this measure.

Reference Tables

Table 12. Window Film[468]

Indianapolis

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	426	0.15	-3.96
Big Box Retail	350	0.12	-3.39
Fast Food Restaurant	317	0.14	-5.06
Full Service Restaurant	304	0.17	-7.07
Light Industrial	285	0.14	-4.00
Primary School	498	0.22	-7.40
Small Office	309	0.13	-2.70
Small Retail	323	0.15	-4.48
Warehouse	285	0.14	-4.00
Other	344	0.00	-4.67

South Bend

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	352	0.01	-3.68
Big Box Retail	319	0.08	-2.91
Fast Food Restaurant	260	0.02	-5.21
Full Service Restaurant	260	0.08	-7.02
Light Industrial	231	0.14	-4.25
Primary School	421	0.26	-6.62
Small Office	280	0.12	-2.62
Small Retail	289	0.12	-4.63
Warehouse	231	0.14	-4.25
Other	294	0.00	-4.58

[468] Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Evansville

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	586	0.15	-3.12
Big Box Retail	457	0.16	-2.43
Fast Food Restaurant	391	0.14	-4.20
Full Service Restaurant	376	0.17	-5.64
Light Industrial	329	0.14	-3.59
Primary School	537	0.18	-6.76
Small Office	369	0.13	-1.92
Small Retail	416	0.16	-3.38
Warehouse	329	0.14	-3.59
Other	421	0.00	-3.85

Ft. Wayne

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	335	0.15	-4.12
Big Box Retail	305	0.16	-3.35
Fast Food Restaurant	258	0.14	-5.11
Full Service Restaurant	254	0.19	-7.43
Light Industrial	199	0.16	-4.34
Primary School	442	0.39	-6.83
Small Office	265	0.14	-2.91
Small Retail	273	0.16	-4.79
Warehouse	199	0.16	-4.34
Other	281	0.00	-4.80

Terre Haute

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	417	0.13	-4.20
Big Box Retail	382	0.09	-2.13
Fast Food Restaurant	306	0.14	-4.20
Full Service Restaurant	310	0.17	-5.47
Light Industrial	273	0.09	-3.41
Primary School	505	0.20	-5.53
Small Office	304	0.11	-1.91
Small Retail	352	0.11	-3.07
Warehouse	273	0.09	-3.41
Other	347	0.00	-3.70

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

Roof Insulation (Retrofit – New Equipment)

Official Measure Code: CI-Shell-RoofInsul-1

Description

This section covers improvements to the roof insulation in commercial buildings. Roof insulation R-value is assumed to increase to R-18 from the baseline level assumed for each building type. Energy and demand saving are realized through reductions in the building heating and cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per thousand square feet of installed insulation.

Definition of Efficient Equipment

The efficient condition is R-18 insulation on the roof.

Definition of Baseline Equipment

The baseline condition by building type is shown in the table below:

Building Type	Baseline R-Value
Assembly	R-12
Big Box Retail	R-13.5
Fast Food	R-13.5
Full Service Restaurant	R-13.5
Light Industrial	R-12
School	R-13.5
Small Office	R-13.5
Small Retail	R-13.5

Deemed Calculation for this Measure

Annual kWh Savings = $SF / 1000 * \Delta kWh_{kSF}$

Summer Coincident Peak kW Savings = $SF / 1000 * \Delta kW_{kSF} * 0.74$

Annual MMBtu Increase = $SF / 1000 * \Delta MMBtu_{kSF}$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years[469].

[469] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

Deemed Measure Cost

The full installed cost for retrofit applications is $1.36 per square foot[470].

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

Coincidence Factor

The coincidence factor is 0.74[471].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = SF / 1000 * \Delta kWh_{kSF}$$

Where:

SF = The square footage of the roof. To be collected with the incentive form.

ΔkWh_{kSF} = the kWh savings per thousand square feet of roof area. This depends on the building type and region in Indiana, and can be found in the lookup table below.

Summer Coincident Peak Demand Savings

$$\Delta kW = SF / 1000 * \Delta kW_{kSF} * CF$$

Where:

ΔkW_{kSF} = the kW savings per thousand square feet of roof area. This depends on the building type and region in Indiana, and can be found in the lookup table below.

CF = The summer coincident peak factor, or 0.74.

Baseline Adjustment

There are no expected future code changes to affect this measure.

[470] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Cost Values and Summary Documentation”, California Public Utilities Commission, December 16, 2008.

[471] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = SF / 1000 * \Delta MMBtu_{kSF}$

Where:

$\Delta MMBtu_{kSF}$ = unit gas savings per thousand square feet of roof space. See lookup table below.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Reference Tables

Roof Insulation[472]

Building	City	ΔkWh$_{kSF}$	ΔkW$_{kSF}$	ΔMMBtu$_{kSF}$
Assembly	Evansville	40	0.074	2.07
	Ft. Wayne	39	0.050	4.17
	Indianapolis	48	0.074	3.36
	South Bend	31	0.000	3.26
	Terre Haute	53	0.082	3.60
Big Box Retail	Evansville	6	0.045	1.90
	Ft. Wayne	4	0.025	3.12
	Indianapolis	5	0.041	2.55
	South Bend	1	0.022	2.52
	Terre Haute	1	0.022	2.67
Fast Food Restaurant	Evansville	80	0.000	3.40
	Ft. Wayne	39	0.050	3.80
	Indianapolis	60	0.050	3.75
	South Bend	38	0.000	3.40
	Terre Haute	77	0.050	4.3
Full Service Restaurant	Evansville	72	0.050	3.20
	Ft. Wayne	75	0.025	5.15
	Indianapolis	84	0.050	4.95
	South Bend	72	0.025	5.08
	Terre Haute	66	0.025	3.58
Light Industrial	Evansville	73	0.022	2.87
	Ft. Wayne	53	0.014	4.41
	Indianapolis	65	0.019	3.96
	South Bend	58	0.019	4.16
	Terre Haute	65	0.019	3.30
Primary School	Evansville	196	0.298	4.52
	Ft. Wayne	106	0.232	4.48
	Indianapolis	135	0.116	4.23
	South Bend	110	0.108	4.33
	Terre Haute	181	0.110	5.05
Small Office	Evansville	57	0.040	2.02
	Ft. Wayne	38	0.06	3.12
	Indianapolis	50	0.04	2.76

[472] Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Building	City	ΔkWh_{kSF}	ΔkW_{kSF}	$\Delta MMBtu_{kSF}$
	South Bend	39	0.04	2.84
	Terre Haute	50	0.040	2.48
Small Retail	Evansville	84	0.062	3.20
	Ft. Wayne	68	0.05	4.66
	Indianapolis	84	0.08	4.20
	South Bend	72	0.05	4.50
	Terre Haute	81	0.047	3.77
Warehouse	Evansville	73	0.022	2.87
	Ft. Wayne	54	0.02	4.34
	Indianapolis	60	0.121	7.53
	South Bend	23	0.011	7.32
	Terre Haute	65	0.019	3.30

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

High Performance Glazing (Retrofit – Early Replacement)

Official Measure Code: CI-Shell-HPGlaz-1

Description

This section covers installation of high performance glazing in commercial buildings. The baseline condition is assumed to be double pane clear glass with a solar heat gain coefficient of 0.73 and U-value of 0.72 Btu/hr-SF-deg F. The efficient glazing must have a solar heat gain coefficient of 0.40 or less and U-value of 0.57 Btu/hr-SF-deg F or less. Energy and demand saving are realized through reductions in the building heating and cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Indiana climate and building practices. Energy and demand impacts are normalized per 100 square feet of window.

Definition of Efficient Equipment

The efficient condition is a window with a U-value of 0.57 and a solar heat gain coefficient of 0.4.

Definition of Baseline Equipment

The baseline condition is a window with a U-value of 0.72 and a solar heat gain coefficient of 0.73.

Deemed Calculation for this Measure

$$\text{Annual kWh Savings} = SF / 100 * (\Delta kWh_{100SF})$$

$$\text{Summer Coincident Peak kW Savings} = SF / 100 * (\Delta kW_{100SF}) * 0.74$$

$$\text{Annual MMBTU Increase} = SF / 100 * (\Delta MMBtu_{100SF})$$

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 20 years[533][473] .

Deemed Measure Cost

The full installed cost for retrofit applications is $54.82 per square foot of window[474].

Deemed O&M Cost Adjustments

There are no expected O&M cost adjustments for this measure.

[473] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

[474] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

Coincidence Factor

The coincidence factor is 0.74[475].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = SF / 100 * (\Delta kWh_{100SF})$$

Where:

SF = glazing surface area of installed window, not including frame (square feet).
ΔkWh_{100SF} = the kWh savings per 100 square feet of window space. See lookup table below.

Summer Coincident Peak Demand Savings

$$\Delta kW = SF / 100 * (\Delta kW_{100SF}) * CF$$

Where:

ΔkW_{100SF} = the kW savings per 100 square feet of window space. See lookup table below.
CF = The summer coincident peak factor, or 0.74.

Baseline Adjustment

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = SF / 100 * (\Delta MMBtu_{100SF})$$

Where:

$\Delta MMBtu_{100SF}$ = unit gas savings per 100 square feet of window space. See lookup table below.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

[475] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Reference Tables

High Performance Windows[476]

Indianapolis

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	376	0.15	-0.67
Big Box Retail	317	0.12	-0.81
Fast Food Restaurant	316	0.14	-0.84
Full Service Restaurant	331	0.17	-0.99
Light Industrial	272	0.14	-1.69
Primary School	535	0.23	-2.97
Religious Worship	210	0.19	-0.25
Small Office	300	0.14	-0.57
Small Retail	326	0.16	-1.13
Warehouse	272	0.14	-1.69
Other	326	0.00	-1.16

South Bend

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	301	0.01	-0.96
Big Box Retail	291	0.09	-0.81
Fast Food Restaurant	266	0.03	-0.43
Full Service Restaurant	289	0.08	-0.52
Light Industrial	212	0.14	-1.83
Primary School	450	0.26	-2.44
Small Office	273	0.13	-0.42
Small Retail	298	0.13	-0.88
Warehouse	212	0.14	-1.83
Other	288	0.00	-1.03

[476] Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Evansville

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	510	0.15	-1.00
Big Box Retail	406	0.17	-0.78
Fast Food Restaurant	378	0.15	-0.91
Full Service Restaurant	389	0.17	-1.08
Light Industrial	320	0.14	-1.85
Primary School	574	0.19	-3.09
Small Office	351	0.13	-0.46
Small Retail	404	0.16	-1.04
Warehouse	320	0.14	-1.85
Other	406	0.00	-1.34

Ft. Wayne

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	287	0.16	-0.74
Big Box Retail	280	0.17	-0.11
Fast Food Restaurant	263	0.14	-0.40
Full Service Restaurant	289	0.19	-0.72
Light Industrial	215	0.16	-1.26
Primary School	470	0.20	-2.35
Small Office	261	0.14	-0.47
Small Retail	285	0.17	-0.79
Warehouse	215	0.16	-1.26
Other	285	0.00	-0.90

Terre Haute

Building Type	ΔkWh_{100SF}	ΔkW_{100SF}	$\Delta MMBtu_{100SF}$
Assembly	362	0.14	-0.52
Big Box Retail	338	0.10	-0.20
Fast Food Restaurant	306	0.14	-0.22
Full Service Restaurant	327	0.17	-0.17
Light Industrial	283	0.11	-0.90
Primary School	539	0.21	-1.81
Small Office	292	0.11	-0.14
Small Retail	344	0.11	-0.43
Warehouse	283	0.11	-0.90
Other	342	0.00	-0.47

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

Engineered Nozzles (Time of Sale, Retrofit - Early Replacement)

Official Measure Code: CI-Proc-CANozzle-1

Description

Engineered nozzles use compressed air to entrain and amplify atmospheric air into a stream, thus increasing pressure with minimal compressed air use. They are able to induce a large airflow entrainment while still using a smaller volume of air than open jets. The velocity of the resulting airflow is reduced, but the mass flow of the air is increased, thus increasing the cooling and drying effect. Energy savings result due to a decrease in compressor work that is required to provide the nozzles with compressed air. Engineered nozzles have the added benefits of noise reduction and improved safety in systems with greater than 30 psig.

Definition of Efficient Equipment

The efficient condition assumes an engineered nozzle is equipped to the end of a pneumatic tool.

Definition of Baseline Equipment

The baseline condition assumes an open copper tube or an air gun with an open end.

Deemed Savings for this Measure

Annual kWh Savings	= 0.0145 x ($FLOW_{baseline}$ - $FLOW_{eng}$) X HOURS
Summer Coincident Peak kW Savings	= 0.0109 x ($FLOW_{baseline}$ - $FLOW_{eng}$)
Deemed Lifetime of Efficient Equipment	= 15 years[477]

Deemed Measure Cost

$14

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.75[478]

[477] PA Consulting Group (2009). Business Programs: Measure Life Study. Prepared for State of Wisconsin Public Service Commission
[478] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys. Based on 4p-5p peak

Calculation of Savings

Energy Savings

$\Delta kWh = (FLOW_{baseline} - FLOW_{eng}) \times kW_{scfm} \times \%USE \times HOURS$

Where:

kW_{scfm} = the average amount of electrical demand needed to produce one cubic foot of air at 100 PSI
= 0.29

$FLOW_{baseline}$ = The flow rate of compressed air from an open end (SCFM[479])

$FLOW_{eng}$ = The flow rate of compressed air from an engineered nozzle (SCFM)
= Depending on size of nozzle:

	Open Flow (SCFM)[480] $FLOW_{baseline}$	Engineered Nozzle (SCFM)[481] $FLOW_{eng}$	ΔSCFM
1/8" Nozzle	21	6	15
1/4" Nozzle	58	11	47

%USE = percent of the compressor total operating hours that the nozzle is in use (5% for 3 seconds of use per minute)
= 0.05[482]

HOURS = annual operating hours of the compressed air system
= If site specific value is unknown, assume vales based on number of facility shifts as below:

No. of Shifts	HOURS	Description
Single Shift(8/5)	1976	7am – 3pm, weekdays, minus holidays and scheduled downtime
2-Shift	3952	7am – 11pm, weekdays, minus holidays and scheduled downtime
3-Shift	5928	24 hours per day, weekdays, minus holidays and scheduled
4-Shift	8320	24 hours per day, 7 days a week minus holidays and scheduled

479 SCFM is flowrate (cfm) at standard conditions of temperature, pressure, and humidity.
480 Machinery's Handbook 25th Edition.
481 Survey of Engineered Nozzle Suppliers
482 Assumes 50% handheld air guns and 50% stationary air nozzles. Manual air guns tend to be used less than stationary air nozzles, and a conservative estimate of 1 second of blow-off per minute of compressor run time is assumed. Stationary air nozzles are commonly more wasteful as they are often mounted on machine tools and can be manually operated resulting in the possibility of a long term open blow situation. An assumption of 5 seconds of blow-off per minute of compressor run time is used.

Summer Coincident Peak Demand Savings

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

Where:

ΔkWh	= Energy Savings, calculated above
HOURS	= Operating Hours, see above
CF	= Peak coincidence factor
	= 0.75

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date:	January 10, 2013
End date:	TBD

Insulated Pellet Dryers (Retrofit)

Official Measure Code: CI-Proc-InsulPellet-1

Description

Resin pellets used in injection molders and extruders are typically dried using electrically heated and desiccant dried air. Flexible ducts in the 3" to 8" diameter size range circulate the drying air. Air temperatures usually range from 160°F to 200°F. Un-insulated duct heat loss must be replaced by electric resistance heaters. Most facilities have pellet dryers running constantly to maintain pellet dryness at all times.

Definition of Efficient Equipment

The efficient condition is a pellet dryer with insulation on the heat ducts.

Definition of Baseline Equipment

The baseline condition is pellet dryer with un-insulated heat ducts.

Deemed Savings for this Measure

Annual kWh Savings $= L \times (kW_{baseline} - kW_{eff}) \times HOURS$
Summer Coincident Peak kW Savings
$= L \times (kW_{baseline} - kW_{eff}) \times CF$

Deemed Lifetime of Efficient Equipment

5 years[483]

Deemed Measure Cost

Incremental costs are based on linear feet and diameter of heating ducts.

Incremental Capital Cost[484]

Diameter of Pipe (in.)	Incremental Cost of Insulation ($/ft.)
3"	$33
4"	$43
5"	$54
6"	$65
8"	$86

Deemed O&M Cost Adjustments

n/a

483 Engineering Judgment
484 Based on a review of available manufacturer pricing information

Coincidence Factor

0.75[485]

REFERENCE SECTION

Calculation of Savings

Energy Savings

Where:

$\Delta kWh = L \times (kW_{baseline} - kW_{eff}) \times HOURS$

ΔkWh = non-coincident demand savings
L = Length of pipe to be insulated (ft.)
$KW_{baseline}$ = maximum hourly demand at technology level without insulation
= See table below
kW_{eff} = maximum hourly demand at technology level with pipe insulation
= See table below
HOURS = annual operating hours
= 4962[486]

Summer Coincident Peak Demand Savings

$\Delta kW = L \times (kW_{baseline} - kW_{eff}) \times CF$

Where:

CF = Summer Coincident Peak Factor
= 0.75[487]

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

[485] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys.
[486] State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Parameter Development. August 2009. PA Consulting Group Inc.
[487] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys.

Reference Tables

Table 13. Electric Demand for Load Temperatures and Duct Diameters

Temperature (°F)	Duct Diameter (in)	$KW_{baseline}$	$KW_{energyefficientmethod}$	ΔKW
160	3	0.03/ft	0.01/ft	0.02/ft
	4	0.04/ft	0.01/ft	0.03/ft
	5	0.05/ft	0.01/ft	0.04/ft
	6	0.06/ft	0.01/ft	0.05/ft
	8	0.09/ft	0.01/ft	0.08/ft
170	3	0.03/ft	0.01/ft	0.03/ft
	4	0.05/ft	0.01/ft	0.04/ft
	5	0.06/ft	0.01/ft	0.05/ft
	6	0.07/ft	0.01/ft	0.06/ft
	8	0.10/ft	0.01/ft	0.09/ft
180	3	0.04/ft	0.01/ft	0.03/ft
	4	0.05/ft	0.01/ft	0.04/ft
	5	0.07/ft	0.01/ft	0.06/ft
	6	0.08/ft	0.01/ft	0.07/ft
	8	0.11/ft	0.01/ft	0.10/ft
190	3	0.04/ft	0.01/ft	0.04/ft
	4	0.06/ft	0.01/ft	0.05/ft
	5	0.07/ft	0.01/ft	0.06/ft
	6	0.09/ft	0.01/ft	0.08/ft
	8	0.13/ft	0.02/ft	0.11/ft
200	3	0.05/ft	0.01/ft	0.04/ft
	4	0.07/ft	0.01/ft	0.06/ft
	5	0.08/ft	0.01/ft	0.07/ft
	6	0.10/ft	0.01/ft	0.09/ft
	8	0.14/ft	0.02/ft	0.12/ft

Version Date & Revision History

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Injecting Molding Barrel Wrap (Retrofit – New Equipment)

Official Measure Code: CI-Proc-IMMWrap-1

Description

Removable insulated blankets enclose the cylindrical barrels of an injection molding machine. Surface temperatures of the barrels range from 300°F to 600°F, depending on the resins processed. Barrels are heated either with electric resistance band heaters or by friction from the mechanical screw which shears plastic material in the barrel generating frictional heat. Insulated blankets minimize the use of resistance heating without affecting temperature control of the resin. Barrel wraps are held in place by straps. Blankets are available either in standard sizes or can be custom manufactured.

Definition of Efficient Equipment

The efficient condition is assumed to be an injection molding machine with an insulating blanket or vest wrapped around the barrel.

Definition of Baseline Equipment

The baseline condition is assumed to be an injection molding machine with no added insulation.

Deemed Savings for this Measure

Annual kWh Savings	$= (\Delta E_{Loss} * LEN_{Barrel} * D_{Barrel} * \pi) / 1000 * HOURS$
Summer Coincident Peak kW Savings	$= (\Delta E_{Loss} * LEN_{Barrel} * D_{Barrel} * \pi) / 1000 * CF$
Deemed Lifetime of Efficient Equipment	= 5 years[488]

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.75[489]

[488] Engineering judgment
[489] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys. Pending verification based on information to be provided by the utilities.

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = (\Delta E_{Loss} * LEN_{Barrel} * D_{Barrel} * \pi) / 1000 * HOURS$

Where:

ΔE_{Loss} = The difference in heat loss (measured in watts/ft^2 needed to replace lost heat) between an injection molding barrel with insulation compared to an injection molding barrel without insulation. This is dependent on the operating temperature (site specific) and the thickness of the insulation (site specific). See the table "Calculating Barrel Heat Loss" in the reference table section for associated values.

LEN_{Barrel} = The length of the barrel
= Actual installed

D_{Barrel} = The diameter of the barrel
= Actual installed

π = 3.14159

1000 = conversion factor for watts to kilowatts

HOURS = Annual operating hours
= If actual operating hours are unknown, assume 3952[490].

Summer Coincident Peak Demand Savings

$\Delta kW = (\Delta E_{Loss} * LEN_{Barrel} * D_{Barrel} * \pi) / 1000 * CF$

Where:

CF = Summer Peak Coincidence Factor
= 0.75

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

[490] Default annual operating hours estimate assumes equipment operates continuously on a typical 2-shift operation (7am – 11pm, weekdays, minus some holidays and scheduled down time).

Reference Tables

Calculating Barrel Heat Loss[491] Operating T...	No Insulation (Watts/ ft^2)	1” Insulation (Watts/ft^2)	1.5” Insulation (Watts/ft^2)
300	180	18.6	12.4
325	210	20.9	14
350	243	23.4	15.6
375	275	26	17.3
400	313	29	19
425	350	31.5	21
450	387	34.3	22.9
475	425	37.2	24.8
500	465	40.1	25.8
525	505	43.2	26.9
550	550	46.5	28.3
575	605	49.9	29.9
600	660	54.1	32.1

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[491] Industrial Modeling Supplies (2009). Reference/Conversion Chart. http://www.imscompany.com/pdf/Tech%20Tips%20&%20Conversion%20and%20Reference%20Charts.pdf

ENERGY STAR Hot Food Holding Cabinet (Time of Sale)

Official Measure Code: CI-Food-HoldCab-1

Description

Commercial insulated hot food holding cabinet models that meet program requirements incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door electric gaskets, auto-door closures, or dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. This means that qualified hot food holding cabinets are more efficient at maintaining food temperature while using less energy.

Definition of Efficient Equipment

The efficient equipment is assumed to be an ENERGY STAR qualified hot food holding cabinet with an idle energy rate of 0.04kW/ft^3

Definition of Baseline Equipment

The baseline equipment is assumed to be a standard hot food holding cabinet with an idle energy rate of 0.1kW/ft^3

Deemed Savings for this Measure

Annual kWh Savings

Full Size	Three-Quarter Size	Half Size
5,256	2,847	1,862

Summer Coincident Peak kW Savings

Full Size	Three-Quarter Size	Half Size
0.80	0.44	0.29

Deemed Lifetime of Efficient Equipment

12 years[492]

Deemed Measure Cost

The incremental cost for Energy Star hot food holding cabinet is assumed to be $1,110[493]

Deemed O&M Cost Adjustments

n/a

[492] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

[493] NYSERDA Deemed Savings Database

Coincidence Factor

0.84[494]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = (W_{foot\ base} - W_{foot\ eff}) \times VOLUME / 1000 \times HOURS$

Where:

HOURS = Annual operating hours
= 5475[495]

Summer Coincident Peak Demand Savings

$\Delta kW = (W_{foot\ base} - W_{foot\ eff}) \times VOLUME / 1000 \times CF$

Where:

$W_{foot\ base}$ = the electrical demand per cubic foot of the baseline equipment
$W_{foot\ eff}$ = the electrical demand per cubic foot of the efficient equipment
VOLUME = the internal volume of the holding cabinet (ft^3)
1,000 = conversion of W to kW

Parameter	Full Size	Three-Quarter Size	Half Size
VOLUME[496]	20	12	8
$W_{foot\ base}$	70	70	70
$W_{foot\ eff}$	22	27	29
kW_{save}	0.96	0.52	0.34

CF = Summer Peak Coincidence Factor
= 0.84

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

494 RLW Analytics. Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures. Spring 2007.
495 Food Service Technology Center (FSTC), based on assumption that restaurant is open 15 hours a day, 365 days a year.
496 Sizes are from ENERGY STAR calculator

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables
n/a

Version Date & Revision History

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Steam Cookers (Time of Sale)

Official Measure Code: CI-Food-StmCook-1

Description

Energy efficient steam cookers that have earned the ENERGY STAR offer shorter cook times, higher production rates, and reduced heat loss due to better insulation and more efficient steam delivery system. Energy usage calculations are based on 12 hours a day, 365 days per year, with one preheat and cooking 100 pounds per day of food.

Definition of Efficient Equipment

The efficient condition assumes the installation of an ENERGY STAR qualified steam cooker.

Definition of Baseline Equipment

The baseline condition assumes a conventional boiler-style steam cooker meeting minimum federal standards for electricity and water consumption.

Deemed Calculations for this Measure

Annual kWh Savings = $kWH_{base} - kWh_{eff}$

Summer Coincident Peak kW Savings = (Annual kWh Savings / HOURS) x CF

Deemed Lifetime of Efficient Equipment

12 years[497]

Deemed Measure Cost

The incremental cost of an ENERGY STAR steam cooker is $3500[498]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.84[499]

[497] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/esteamercalc.php
[498] Average of NYSERDA Deemed Savings Database and Energy Star website.
[499] RLW Analytics. Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures. Spring 2007.

REFERENCE SECTION

Calculation of Savings

Energy Savings

kWH = [LB x E_{FOOD}/EFF + IDLE x ($HOURS_{DAY}$ – LB/PC – PRE_{TIME} /60) + PRE_{ENERGY}] x DAYS

ΔkWh = kWH_{base} - kWh_{eff}

Where:

kWH_{base} = the annual energy usage of the baseline equipment calculated using baseline values

kWH_{eff} = the annual energy usage of the efficient equipment calculated using efficient values $HOURS_{DAY}$

= Daily operating hours

= 12[500]

PRE_{TIME} = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on

= 15 min/day[501]

PRE_{ENERGY} = Preheat energy (kWh/day)

= 1.5 kWh/day[502]

E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food

= 0.0308[503]

DAYS = Operating days per year

= 365

The following variables are dependent on the pan capacity of efficient equipment which is a site specific variable. See the 'Reference Tables' section for the associated values.

EFF = Heavy load cooking energy efficiency (%) IDLE

= Idle energy rate

PC = Production capacity (lbs/hr)

LB = Pounds of food cooked per day (lb/day)

500 Food Service Technology Center (FSTC), based on assumption that restaurant is open 12 hours a day, 365 days a year.

501 FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.

502 Ibid.

503 American Society for Testing and Materials. Industry Standard.

Summary Coincident Peak Demand Savings

$\Delta kW = (\Delta kWh / HOURS) \times CF$

Where:

ΔkWh = Annual energy savings (kWh) HOURS
= Equivalent full load hours
= 4380

CF = Summer Peak Coincidence Factor for measure
= 0.84

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

Where

$\Delta Water = (Rate_{base} – Rate_{eff}) \times EFLH$
$= 30 \times EFLH$

$\Delta Water$ = Annual water savings (gal)

$Rate_{base}$ = Water consumption rate (gal/h) of baseline equipment
= 40[504]

$Rate_{eff}$ = Water consumption rate (gal/h) of baseline equipment
= 10[505]

EFLH = Equivalent full load hours
= 4380

Deemed O&M Cost Adjustment Calculation

n/a

Reference Tables

Values for ASTM parameters for baseline and efficient conditions (unless otherwise noted) were determined by FSTC according to ASTM F1484, the Standard Test Method for Performance of Steam Cookers. These parameters include the three of the four listed below: Idle Energy Rate, Production Capacity, and Heavy Load Cooking Efficiency. Pounds of Food Cooked per Day based on the default value for a 3 pan steam cooker (100 lbs from FSTC) and scaled up based on the assumption that steam cookers with a greater number of pans cook larger quantities of food per day. It is not known which specific models were tested but the values presented are thought to be the averages of tested models.

[504] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.
[505] Ibid.

Parameters that vary with number of pans:

# of Pans	Parameter	Baseline Model	Efficient Model
3	Idle Energy Rate (kW)[506]	1	0.24
	Production Capacity (lb/h)	70	50
	Pounds of Food Cooked per Day	100	100
	Heavy Load Cooking Energy Efficiency[507]	20%	59%
4	Idle Energy Rate (kW)	1.325	0.27
	Production Capacity (lb/h)	87	67
	Pounds of Food Cooked per Day	128	128
	Heavy Load Cooking Energy Efficiency	20%	52%
5	Idle Energy Rate (kW)	1.675	0.24
	Production Capacity (lb/h)	103	83
	Pounds of Food Cooked per Day	160	160
	Heavy Load Cooking Energy Efficiency	20%	62%
6	Idle Energy Rate (kW)	2	0.31
	Production Capacity (lb/h)	120	100
	Pounds of Food Cooked per Day	192	192
	Heavy Load Cooking Energy Efficiency	20%	62%

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[506] Efficient values calculated from a list of ENERGY STAR qualified products. See “ES Steam Cooker Analysis.xls” for details.
[507] Ibid.

ENERGY STAR Fryers (Time of Sale)

Official Measure Code: CI-Food-Fryer-1

Description

Commercial fryers that have earned the ENERGY STAR offer shorter cook times and higher production rates through advanced burner and heat exchanger designs. Frypot insulation reduces standby losses resulting in a lower idle energy rate. Fryers that have earned the ENERGY STAR are up to 30% more efficient than standard models. Energy savings estimates are based on a 15" fryer.

Definition of Efficient Equipment

The efficient equipment is assumed to be an ENERGY STAR qualified electric fryer

Definition of Baseline Equipment

The baseline equipment is assumed to be a standard electric fryer with a heavy load efficiency of 75%.

Deemed Savings for this Measure

Annual kWh Savings = 982.71 kWh/yr

Summer Coincident Peak kW Savings = 0.22 kW

Deemed Lifetime of Efficient Equipment

12 years[508]

Deemed Measure Cost

The incremental cost for commercial combination ovens is assumed to be $500[509]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.84[510]

REFERENCE SECTION

[508] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/efryer.php
[509] NYSERDA Deemed Savings Database
[510] RLW Analytics. Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures. Spring 2007.

Calculation of Savings

Energy Savings

$$kWH = [LB \times E_{FOOD}/EFF + IDLE/1000 \times (HOURS_{DAY} - LB/PC - PRE_{TIME}/60) + PRE_{ENERGY}] \times DAYS$$

Where:

ΔkWh = $kWH_{base} - kWh_{eff}$

KWH_{base} = the annual energy usage of the baseline equipment calculated using baseline values

KWH_{eff} = the annual energy usage of the efficient equipment calculated using efficient values

$HOURS_{DAY}$ = Daily operating hours
= 16[511]

PRE_{TIME} = Preheat time (min/day), the amount of time it takes a fryer to reach operating temperature when turned on
= 15 min/day[512]

E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food
= 0.167[513]

LB = Pounds of food cooked per day (lb/day)
= 150[514]

DAYS = 365

EFF = Heavy load cooking energy efficiency

(%) IDLE = Idle energy rate

PC = Production capacity (lbs/hr)

PRE_{ENERGY} = Preheat energy (kWh/day)

[511] Food Service Technology Center (FSTC), based on assumption that restaurant is open 16 hours a day, 365 days a year.
[512] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 7: Fryers.
[513] American Society for Testing and Materials. Industry Standard for Commercial Ovens.
[514] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Performance Metrics: Baseline and Efficient Values[515]

Metric	Baseline Model	Energy Efficient Model
PREENERGY	2.3	1.7
IDLE	1.05	0.84
EFF	75%	84%
PC	65	70

Summary Coincident Peak Demand Savings

ΔkW = (ΔkWh / HOURS) x CF

Where:

ΔkWh = Annual energy savings (kWh)
HOURS = Equivalent full load hours
= 5840
CF = Summer Peak Coincidence Factor for measure
= 0.84

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

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[515] Baseline values based on assumptions from FSTC life cycle cost calculator. Efficient values reflect averages from a list of qualifying models found on the ENERGY STAR website (accessed June 2010)

Energy Star Combination Oven (Time of Sale)

Official Measure Code: CI-Food-CombiOven-1

Description

A combination oven is a convection oven that includes the added capability to inject steam into the oven cavity and typically offers at least three distinct cooking modes.

Definition of Efficient Equipment

The efficient equipment is assumed to be an electric combination oven with a heavy load cooking energy efficiency of at least 60%.

Definition of Baseline Equipment

The baseline equipment is assumed to be a typical low-efficiency oven with a heavy load efficiency of 44%.

Deemed Savings for this Measure

Annual kWh Savings = 18,432 kWh

Summer Coincident Peak kW Savings = 3.53 kW

Deemed Lifetime of Efficient Equipment

12 years[516]

Deemed Measure Cost

The incremental cost for commercial combination ovens is assumed to be $2,125[517]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.84[518]

[516] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php
[517] NYSERDA Deemed Savings Database
[518] RLW Analytics. Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures. Spring 2007.

REFERENCE SECTION

Calculation of Savings

Energy Savings

Where:

kWH	= [LB x E_{FOOD}/EFF + IDLE x ($HOURS_{DAY}$ – LB/PC – PRE_{TIME} /60) + PRE_{ENERGY}] x DAYS
ΔkWh	= kWH_{base} - kWh_{eff}
kWH_{base}	= the annual energy usage of the baseline equipment calculated using baseline values
kWH_{eff}	= the annual energy usage of the efficient equipment calculated using efficient values
$HOURS_{DAY}$	= Daily operating hours = 12[519]
DAYS	= Days per year of operation = 365
PRE_{TIME}	= Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on = 15 min/day[520]
E_{FOOD}	= ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food = 0.0732[521]
LB	= Pounds of food cooked per day (lb/day) = 200[522]
EFF	= Heavy load cooking energy efficiency
(%) IDLE	= Idle energy rate
PC	= Production capacity (lbs/hr)
PRE_{ENERGY}	= Preheat energy (kWh/day)

[519] Food Service Technology Center (FSTC), based on assumption that restaurant is open 12 hours a day, 365 days a year.
[520] Food Service Technology Center (2002). Commercial Cooking Appliance Technology Assessment. Prepared by Don Fisher.. Chapter 7: Ovens.
[521] American Society for Testing and Materials. Industry Standard for Commercial Ovens.
[522] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Table 14. Performance Metrics: Baseline and Efficient Values[523]

Metric	Baseline Model	Energy Efficient Model
PRE_{ENERGY} (kWh)	3	1.5
IDLE (kW)	7.5	3
EFF	44%	60%
PC (lb/hr)	80	100

Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh / HOURS) x CF

Where:

ΔkWh = Annual energy savings (kWh)
HOURS = Equivalent full load hours
= 4380
CF = Summer Peak Coincidence Factor for measure
= 0.84

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
The water savings for commercial combination ovens are assumed to be 87,600 gallons per year[524]

Deemed O&M Cost Adjustment Calculation
n/a

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[523] Ibid.
[524] Food Service Technology Center (FSTC). Based on assumption that baseline ovens use water at an average rate of 40 gal/h while efficient models use water at an average rate of 20 gal/h

Energy Star Convection Oven (Time of Sale)

Official Measure Code: CI-Food-ConvOven-1

Description

Commercial convection ovens that are ENERGY STAR certified have higher heavy load cooking efficiencies, and lower idle energy rates making them on average about 20 percent more efficient than standard models. Energy savings estimates are for ovens using full size (18" x 36") sheet pans.

Definition of Efficient Equipment

The efficient equipment is assumed to be an ENERGY STAR qualified electric convection oven.

Definition of Baseline Equipment

The baseline equipment is assumed to be a standard convection oven with a heavy load efficiency of 65%.

Deemed Savings for this Measure

Annual kWh Savings = 3,235 kWh

Summer Coincident Peak kW Savings = 0.62 kW

Deemed Lifetime of Efficient Equipment

12 years[525]

Deemed Measure Cost

The incremental cost for commercial convection ovens is assumed to be $1,113[526]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.84[527]

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[525] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

[526] NYSERDA Deemed Savings Database

[527] RLW Analytics. Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures. Spring 2007.

REFERENCE SECTION

Calculation of Savings

Energy Savings

Where:

$$kWH = [LB \times E_{FOOD}/EFF + IDLE \times (HOURS_{DAY} - LB/PC - PRE_{TIME}/60) + PRE_{ENERGY}] \times DAYS$$

$$\Delta kWh = kWH_{base} - kWh_{eff}$$

kWH_{base} = the annual energy usage of the baseline equipment calculated using baseline values

kWH_{eff} = the annual energy usage of the efficient equipment calculated using efficient values

$HOURS_{DAY}$ = Daily operating hours
= 12[528]

DAYS = Days per year of operation
= 365

PRE_{TIME} = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on
= 15 min/day[529]

E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food
= 0.0732[530]

LB = Pounds of food cooked per day (lb/day)
= 100[531]

EFF = Heavy load cooking energy efficiency (%). See table below.

IDLE = Idle energy rate. See table below.

PC = Production capacity (lbs/hr). See table below.

PRE_{ENERGY} = Preheat energy (kWh/day). See table below.

[528] Food Service Technology Center (FSTC), based on assumption that restaurant is open 12 hours a day, 365 days a year.
[529] Food Service Technology Center (2002). Commercial Cooking Appliance Technology Assessment. Prepared by Don Fisher.. Chapter 7: Ovens.
[530] American Society for Testing and Materials. Industry Standard for Commercial Ovens.
[531] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php

Table 15. Performance Metrics: Baseline and Efficient Values[532]

Metric	Baseline Model	Energy Efficient Model
PRE_{ENERGY} (kWh)	1.5	1
IDLE (kW)	2	1.3[533]
EFF	65%	74%[534]
PC (lb/hr)	70	80

Summary Coincident Peak Demand Savings

ΔkW = (ΔkWh / HOURS) x CF

Where:

ΔkWh = Annual energy savings (kWh)
HOURS = Equivalent full load hours
= 4380
CF = Summer Peak Coincidence Factor for measure
= 0.84

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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532 Ibid.
533 Calculated from list of Energy Star qualified models, http://www.energystar.gov/ia/products/prod_lists/comm_ovens_prod_list.xls
534 Ibid.

ENERGY STAR Griddle (Time of Sale)

Official Measure Code: CI-Food-Griddle-1

Description

ENERGY STAR qualified commercial griddles have higher cooking energy efficiency and lower idle energy rates than standard equipment. The result is more energy being absorbed by the food compared with the total energy use, and less wasted energy when the griddle is in standby mode.

Definition of Efficient Equipment

The efficient equipment is assumed to be an ENERGY STAR qualified griddle that has a cooking energy efficiency greater than 70%.

Definition of Baseline Equipment

The baseline equipment is assumed to be a conventional electric griddle with a cooking energy efficiency of 60%

Deemed Calculations for this Measure

Annual kWh Savings = kWh_{base} - kWh_{eff}

Summer Coincident Peak kW Savings = (Annual kWh Savings / HOURS) x CF

Deemed Lifetime of Efficient Equipment

12 years[535]

Deemed Measure Cost

The incremental cost of an ENERGY STAR griddle is assumed to be $2,090[536].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0.84[537]

REFERENCE SECTION

[535] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/egridcalc.php

[536] New York State Energy Research and Development Agency (NYSERDA) Deemed Savings Database, Rev. 12, 2008.

[537] Verification of summer peak coincidence factor is pending further information from the utilities.

Calculation of Savings

Energy Savings

kWh_i = [LB x E_{FOOD} / EFF_i + $IDLE_i$ x ($HOURS_{DAY}$ – LB / PC_i – PRE_{TIME} / 60) + $PRE_{ENERGY,i}$] x DAYS

ΔkWh = kWh_{base} - kWh_{eff}

Where:

kWh_{base} = the annual energy usage of the baseline equipment calculated using baseline values
(where i = base for all instances of the subscript in the equation above).

kWh_{eff} = the annual energy usage of the efficient equipment calculated using efficient values
(where i = eff for all instances of the subscript in the equation above).

LB = Pounds of food cooked per day
= 100

E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food
= 0.139[538]

EFF_i = Heavy Load Cooking Energy Efficiency; see table below for baseline and efficient values.

$IDLE_i$ = Idle Energy Rate; see table below for baseline and efficient values.

$HOURS_{DAY}$ = Daily operating hours
= 12[539]

PC_i = Production Capacity; see table below for baseline and efficient values.

PRE_{TIME} = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on
= 15 min/day[540]

60 = minutes per hour

$PRE_{ENERGY,i}$ = Preheat energy (kWh/day); see table below for baseline and efficient values.

DAYS = Operating Days per year
= 365

[538] American Society for Testing and Materials. Industry Standard.
[539] Food Service Technology Center (FSTC), based on assumption that restaurant is open 12 hours a day, 365 days a year.
[540] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 3: Griddles.

Table 16. Efficient Griddle Performance Metrics: Baseline and Efficient Values[541]

Parameter	Baseline Model	Efficient Model
Idle Energy Rate (kW)	2.4	0.92
Production Capacity (lb/h)	35	46
PREENERGY	4	2
Heavy Load Cooking Energy Efficiency	60%	75%

Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh / HOURS) x CF

Where:

ΔkWh = Annual energy savings (kWh)
HOURS = annual operating hours
= $HOURS_{DAY}$ * DAYS = 12 * 365 =4380
CF = Summer Peak Coincidence Factor for measure
= 0.84

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[541] An average pan width of 3 ft has been assumed based on a survey of available equipment. Baseline values based on assumptions from FSTC life cycle cost calculator. Efficient values reflect averages from a list of qualifying models found on the ENERGY STAR website (accessed June 2010)

Spray Nozzles for Food Service (Retrofit)

Official Measure Code: CI-SHW-PRSV-1

Description

All pre-rinse valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. They reduce water consumption, water heating cost, and waste water (sewer) charges. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The spray valves usually have a clip to lock the handle in the "on" position. Pre-rinse valves are inexpensive and easily interchangeable with different manufacturers' assemblies. The primary impacts of this measure will be water savings. Energy savings depend on the facility's water heating fuel - if the facility does not have electric water heating, there are no electric savings for this measure; if the facility does not have fossil fuel water heating, there are no MMBtu savings for this measure.

Definition of Efficient Equipment

The efficient equipment is assumed to be a pre-rinse spray valve with a flow rate of 1.6 gallons per minute, and with a cleanability performance of 26 seconds per plate or less

Definition of Baseline Equipment

The baseline equipment is assumed to be a spray valve with a flow rate of 3 gallons per minute.

Deemed Savings for this Measure

Annual kWh Savings[542] $= \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) / 3412$

Summer Coincident Peak kW Savings $= 0$

Annual MMBtu Savings[543] $= \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) \times 10^{-6}$

Deemed Lifetime of Efficient Equipment

5 years[544]

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments

n/a

542 If the facility does not have electric water heating, there are no electric savings for this measure.
543 If the facility does not have fossil fuel water heating, there are no MMBtu savings for this measure.
544 Federal Energy Management Program (2004), How to Buy a Low-Flow Pre-Rinse Spray Valve. Common assumption across efficiency programs.

Coincidence Factor

n/a[545]

REFERENCE SECTION

Calculation of Savings

Energy Savings

If water heating is electric-based:

$\Delta kWh = \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) / 3412$

$\Delta Water$ = Water savings (gallons); see calculation in "Water Impact" section below.

$HOT_{\%}$ = The percentage of water used by the pre-rinse spray valve that is heated
= 69%[546]

8.33 = The energy content of heated water (Btu/gallon/°F)

ΔT = Temperature rise through water heater (°F)
= 70[547]

EFF = Water heater thermal efficiency
= 0.97[548]

10^{-6} = Factor to convert Btu to MMBtu

Summer Coincident Peak Demand Savings

$\Delta kW = 0$

Fossil Fuel Impact Descriptions and Calculation

If water heating is fossil fuel-based:

$\Delta MMBtu = \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) \times 10^{-6}$

$\Delta Water$ = Water savings (gallons); see calculation in "Water Impact" section below.

$HOT_{\%}$ = The percentage of water used by the pre-rinse spray valve that is heated
= 69%

8.33 = The energy content of heated water (Btu/gallon/°F)

ΔT = Temperature rise through water heater (°F)
= 70[549]

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545 No demand savings are claimed for this measure since there is insufficient peak coincident data.

546 Measures and Assumptions for DSM Planning (2009). Navigant Consulting. Prepared for the Ontario Energy Board. This factor is a candidate for future improvement through evaluation.

547 Engineering judgment; assumes typical supply water temperature of 70°F and a hot water storage tank temperature of 140°F.

548 ASHRAE 90.1-2007. Performance requirement for electric resistance water heaters.

EFF = Water heater thermal efficiency
= 0.58[550]
10^{-6} = Factor to convert Btu to MMBtu

Water Impact Descriptions and Calculation

$$\Delta Water = (FLO_{base} - FLO_{eff}) \times 60 \times HOURS_{day} \times 365$$

FLO_{base} = The flow rate of the baseline spray nozzle
= 3 gallons per minute
FLO_{eff} = The flow rate of the efficient equipment
= 1.6 gallons per minute
60 = minutes per hour
365 = days per year
HOURS = Hours used per day – depends on facility type as below:[551]

Facility Type	Hours of Pre-Rinse Spray Valve Use per Day (HOURS)
Full Service Restaurant	4
Other	2
Limited Service (Fast Food)	1

Deemed O&M Cost Adjustment Calculation
n/a

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[549] Engineering judgment; assumes typical supply water temperature of 70°F and a hot water storage tank temperature of 140°F.
[550] Baseline gas water heater thermal efficiency. As submitted in the gas utilities' Proposed predetermined values and protocols –submitted to the OH PUC 2009. Case no. 09-512-GE-UNC.
[551] Hours estimates based on PG&E savings estimates, algorithms, sources (2005). Food Service Pre-Rinse Spray Valves

Refrigerated Case Covers (Time of Sale, New Construction, Retrofit – New Equipment)

Official Measure Code: CI-Refrig-CaseCover-1

Description

By covering refrigerated cases the heat gain due to the spilling of refrigerated air and convective mixing with room air is reduced at the case opening. Continuous curtains can be pulled down overnight while the store is closed, yielding significant energy savings.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a refrigerated case with a continuous cover deployed during overnight periods. Characterization assumes covers are deployed for six hours daily.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a refrigerated case without a cover.

Deemed Calculation for this Measure

Annual kWh Savings	= 346.5 * FEET / COP
Summer Coincident Peak kW Savings	= 0

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 5 years [552].

Deemed Measure Cost

The incremental capital cost for this measure is $42 per linear foot of cover installed including material and labor[553].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0[554].

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552 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

553 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008 <http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip>

554 Assumed that the continuous covers are deployed at night; therefore no demand savings occur during the peak period.

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (LOAD / 12,000) * FEET * (3.516) / COP * ESF * 8,760

Where:

LOAD	= average refrigeration load per linear foot of refrigerated case without night covers deployed = 1,500 Btu/h[555] per linear foot
FEET	= linear (horizontal) feet of covered refrigerated case
12,000	= conversion factor - Btu per ton cooling.
3.516	= conversion factor – Coefficient of Performance (COP) to kW per ton.
COP	= Coefficient of Performance of the refrigerated case. = assume 2.2[556], if actual value is unknown.
ESF	= Energy Savings Factor; reflects the percent reduction in refrigeration load due to the deployment of night covers. = 9%[557]
8,760	= assumed annual operating hours of the refrigerated case

Summer Coincident Peak Demand Savings

ΔkW = 0[558]

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

555 Davis Energy Group, Analysis of Standard Options for Open Case Refrigerators and Freezers, May 11, 2004. Accessed on
7/7/10 <
http://www.energy.ca.gov/appliances/2003rulemaking/documents/case_studies/CASE_Open_Case_Refrig.pdf>

556 Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

557 Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, Southern California Edison, August 8, 1997. Accessed on 7/7/10. <http://www.sce.com/NR/rdonlyres/2AAEFF0B-4CE5-49A5-8E2C-3CE23B81F266/0/AluminumShield_Report.pdf>; Characterization assumes covers are deployed for six hours daily.

558 Assumed that the continuous covers are deployed at night; therefore no demand savings occur during the peak period.

Version Date & Revision History

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Door Heater Controls for Cooler or Freezer (Time of Sale)

Official Measure Code: CI-Refrig-ASHCtrl-1

Description

By installing a control device to turn off door heaters when there is little or no risk of condensation, one can realize significant energy savings. There are two commercially available control strategies that achieve "on-off" control of door heaters based on either (1) the relative humidity of the air in the store or (2) the "conductivity" of the door (which drops when condensation appears). In the first strategy, the system activates your door heaters when the relative humidity in your store rises above a specific setpoint, and turns them off when the relative humidity falls below that setpoint. In the second strategy, the sensor activates the door heaters when the door conductivity falls below a certain setpoint, and turns them off when the conductivity rises above that setpoint.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator utilizing humidity or conductivity control.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline condition is assumed to be a commercial glass door cooler or refrigerator with a standard heated door with no controls installed.

Deemed Calculation for this Measure

Annual kWh Savings	= kWbase * NUMdoors * ESF * BF * 8760
Summer Coincident Peak kW Savings	= 0

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 12 years [559].

Deemed Measure Cost

The incremental capital cost for a humidity-based control is $300 per circuit regardless of the number of doors controlled. The incremental cost for conductivity-based controls is $200[560].

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0%[561].

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559 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

560 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

561 Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings from door heater controls.

REFERENCE SECTION

Calculation of Savings

Energy Savings

Where:

ΔkWH	= kWbase * NUM_{doors} * ESF * BF * 8760
kWbase[562]	= connected load kW for typical reach-in refrigerator or freezer door and frame with a heater. = If actual kWbase is unknown, assume 0.195 kW for freezers and 0.092 kW for coolers.
NUMdoors	= number of reach-in refrigerator or freezer doors controlled by sensor = Actual installed
ESF[563]	= Energy Savings Factor; represents the percentage of hours annually that the door heater is powered off due to the controls. = assume 55% for humidity-based controls, 70% for conductivity-based controls
BF[564]	= Bonus Factor; represents the increased savings due to reduction in cooling load inside the cases, and the increase in cooling load in the building space to cool the additional heat generated by the door heaters. = assume 1.36 for low-temp, 1.22 for medium-temp, and 1.15 for high-temp applications

Summer Coincident Peak Demand Savings

ΔkW[565] = 0

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

[562] A review of TRM methodologies from Vermont, New York, Wisconsin, and Connecticut reveals several different sources for this factor. Connecticut requires site-specific information, whereas New York's characterization does not explicitly identify the kWbase. Connecticut and Vermont provide values that are very consistent, and the simple average of these two values has been used for the purposes of this characterization.

[563] A review of TRM methodologies from Vermont, New York, Wisconsin, and Connecticut reveals several different estimates of ESF. Vermont is the only TRM that provides savings estimates dependent on the control type. Additionally, these estimates are the most conservative of all TRMs reviewed. These values have been adopted for the purposes of this characterization.

[564] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[565] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings from door heater controls.

Deemed O&M Cost Adjustment Calculation
n/a

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ENERGY STAR Ice Machine (Time of Sale, New Construction)

Official Measure Code: CI-Refrig-IceMach-1

Description

This measure relates to the installation of a new ENERGY STAR qualified commercial ice machine. The ENERGY STAR label applied to air-cooled, cube-type machines including ice-making head, self-contained, and remote- condensing units. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a commercial ice machine meeting the minimum ENERGY STAR efficiency level standards.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a commercial ice machine meeting federal equipment standards established January 1, 2010.

Deemed Calculation for this Measure

Annual kWh Savings $= [(kWh_{base} - kWh_{ee}) / 100] \times (0.57 * H) \times 365$

Summer Coincident Peak kW Savings = Annual kWh Savings / (8760 x 0.57) x 0.772

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 9 years[566].

Deemed Measure Cost

The incremental capital cost for this measure is provided below.[567]

Harvest Rate (H)	Incremental Cost
100-200 lb ice machine	$296
201-300 lb ice machine	$312
301-400 lb ice machine	$559
401-500 lb ice machine	$981

566 The following report estimates life of a commercial ice-maker at 7-10 years: Energy Savings Potential for Commercial Refrigeration Equipment, Arthur D. Little, Inc., 1996.

567 These values are from electronic work papers prepared in support of San Diego Gas & Electric's "Application for Approval of Electric and Gas Energy Efficiency Programs and Budgets for Years 2009-2011", SDGE, March 2, 2009. Accessed on 7/7/10 <http://www.sdge.com/regulatory/documents/ee2009-2011Workpapers/SW-ComB/Food%20Service/Food%20Service%20Electic%20Measure%20Workpapers%2011-08-05.DOC>.

Harvest Rate (H)	Incremental Cost
501-1000 lb ice machine	$1,485
1001-1500 lb ice machine	$1,821
>1500 lb ice machine	$2,194

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 77.2%[568].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = [(kWh_{base} - kWh_{ee}) / 100] * (DC * H) * 365$$

Where:

kWh_{base} = maximum kWh consumption per 100 pounds of ice for the baseline equipment
= calculated as shown in the table below using the actual Harvest Rate (H) of the efficient equipment.

kWh_{ee} = maximum kWh consumption per 100 pounds of ice for the efficient equipment
= calculated as shown in the table below using the actual Harvest Rate (H) of the efficient equipment.

[568] Assumes that the summer peak coincidence factor for commercial ice machines is consistent with that of general commercial refrigeration equipment. Characterization assumes a value of 77.2% adopted from the Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, until a region specific study is conducted.

Ice Machine Type	kWh_{base} [569]	$kWhe_{e}$ [570]
Ice Making Head (H < 450)	10.26 - 0.0086*H	9.23 - 0.0077*H
Ice Making Head (H ≥ 450)	6.89 – 0.0011*H	6.20 - 0.0010*H
Remote Condensing Unit, without remote compressor (H < 1000)	8.85 – 0.0038*H	8.05 - 0.0035*H
Remote Condensing Unit, without remote compressor (H ≥ 1000)	5.1	4.64
Remote Condensing Unit, with remote compressor (H < 934)	8.85 – 0.0038*H	8.05 - 0.0035*H
Remote Condensing Unit, with remote compressor (H ≥ 934)	5.3	4.82
Self Contained Unit (H < 175)	18 - 0.0469*H	16.7 - 0.0436*H
Self Contained Unit (H ≥ 175)	9.8	9.11

100 = conversion factor to convert kWh_{base} and kWh_{ee} into maximum kWh consumption per pound of ice.
DC = Duty Cycle of the ice machine
= 0.57[571]
H = Harvest Rate (pounds of ice made per day)
= Actual installed
365 = days per year

Summer Coincident Peak Demand Savings

$\Delta kW = \Delta kWh / (HOURS * DC) * CF$

Where:

HOURS = annual operating hours
= 8760[572]
CF = Summer Peak Coincidence Factor for measure
= 0.772 [573]

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569 Baseline reflects federal standards which apply to units manufactured on or after January 1, 2010 <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div6&view=text&node=10:3.0.1.4.17.8&idno=10>.

570 ENERGY STAR Program Requirements for Commercial Ice Machines, Partner Commitments, U.S. Environmental Protection Agency, Accessed on 7/7/10 <http://www.energystar.gov/ia/partners/product_specs/program_reqs/ice_machine_prog_req.pdf>

571 Duty cycle varies considerably from one installation to the next. TRM assumptions from Vermont, Wisconsin, and New York vary from 40 to 57%, whereas the ENERGY STAR Commercial Ice Machine Savings Calculator < http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls> assumes a value of 75%. A field study of eight ice machines in California indicated an average duty cycle of 57% ("A Field Study to Characterize Water andEnergy Use of Commercial Ice-Cube Machines and Quantify Saving Potential", Food Service Technology Center, December 2007). Furthermore, a report prepared by ACEEE assumed a value of 40% (Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002). This characterization assumed the average value of 57% from the CA study.

572 Unit is assumed to be connected to power 24 hours per day, 365 days per year.

573 Assumes that the summer peak coincidence factor for commercial ice machines is consistent with that of general commercial refrigeration equipment. Characterization assumes a value of 77.2% adopted from the Efficiency Vermont

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
While the ENERGY STAR labeling criteria require that certified commercial ice machines meet certain "maximum potable water use per 100 pounds of ice made" requirements, such requirements are intended to prevent equipment manufacturers from gaining energy efficiency at the cost of water consumptions. A review of the AHRI Certification Directory[574] indicates that approximately 81% of air-cooled, cube-type machines meet the ENERGY STAR potable water use requirement. Therefore, there are no assumed water impacts for this measure.

Deemed O&M Cost Adjustment Calculation
n/a

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Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, until a region specific study is conducted.

[574] AHRI Certification Directory, Accessed on 7/7/10. <http://www.ahridirectory.org/ahridirectory/pages/home.aspx>

Commercial Solid Door Refrigerators & Freezers (Time of Sale, New Construction)

Official Measure Code: CI-Refrig-Ref/Freez-1

Description

This measure relates to the installation of a new reach-in commercial refrigerator or freezer meeting ENERGY STAR efficiency standards. ENERGY STAR labeled commercial refrigerators and freezers are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which will significantly reduce energy consumption. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a solid or glass door refrigerator or freezer meeting the minimum ENERGY STAR efficiency level standards.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a solid or glass door refrigerator or freezer meeting the minimum federal manufacturing standards as specified by the Energy Policy Act of 2005.

Deemed Calculation for this Measure

Annual kWh Savings = $(kWh_{base} - kWh_{ee}) * 365$

Summer Coincident Peak kW Savings = Annual kWh Savings / HOURS * CF

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 12 years [575].

Deemed Measure Cost

The incremental capital cost for this measure is provided below[576].

[575] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[576] Estimates of the incremental cost of commercial refrigerators and freezers varies widely by source. Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002, indicates that incremental cost is approximately zero. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, assumed incremental cost ranging from $75 to $125 depending on equipment volume. ACEEE notes that incremental cost ranges from 0 to 10% of the baseline unit cost <http://www.aceee.org/ogeece/ch5_reach.htm>. For the purposes of this characterization, assume

Type	Refrigerator Incremental Cost	Freezer Incremental Cost
Solid or Glass Door		
0 < V < 15	$143	$142
15 ≤ V < 30	$164	$166
30 ≤ V < 50	$164	$166
V ≥ 50	$249	$407

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 100%[577].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = (kWh_{base} - kWh_{ee}) * 365$

Where:

kWh_{base} = baseline maximum daily energy consumption in kWh
= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in the table below.

Type	kWh_{base}[578]
Solid Door Refrigerator	0.10 * V + 2.04
Glass Door Refrigerator	0.12 * V + 3.34
Solid Door Freezer	0.40 * V + 1.38
Glass Door Freezer	0.75 * V + 4.10

and incremental cost adder of 5% on the full unit costs presented in Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.

[577] The Summer Peak Coincidence Factor is assumed to equal 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.

[578] Energy Policy Act of 2005. Accessed on 7/7/10. <http://www.epa.gov/oust/fedlaws/publ_109-058.pdf>

kWh_{ee}[579] = efficient maximum daily energy consumption in kWh
= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in the table below.

Type	Refrigerator kWh_{ee}	Freezer kWh_{ee}
Solid Door		
0 < V < 15	≤ 0.089V + 1.411	≤ 0.250V + 1.250
15 ≤ V < 30	≤ 0.037V + 2.200	≤ 0.400V – 1.000
30 ≤ V < 50	≤ 0.056V + 1.635	≤ 0.163V + 6.125
V ≥ 50	≤ 0.060V + 1.416	≤ 0.158V + 6.333
Glass Door		
0 < V < 15	≤ 0.118V + 1.382	≤ 0.607V + 0.893
15 ≤ V < 30	≤ 0.140V + 1.050	≤ 0.733V – 1.000
30 ≤ V < 50	≤ 0.088V + 2.625	≤ 0.250V + 13.500
V ≥ 50	≤ 0.110V + 1.500	≤ 0.450V + 3.500

V = the chilled or frozen compartment volume (ft^3) (as defined in the Association of Home Appliance Manufacturers Standard HRF1–1979)
= Actual installed

365 = days per year

Summer Coincident Peak Demand Savings

$\Delta kW = \Delta kWh / HOURS * CF$

Where:

HOURS = equipment is assumed to operate continuously, 24 hours per day, 365 days per year.
= 8760

CF = Summer Peak Coincidence Factor for measure
= 1.0 [580]

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

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579 ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency, Accessed on 7/7/10. <http://www.energystar.gov/ia/partners/product_specs/program_reqs/commer_refrig_glass_prog_req.pdf>

580 The Summer Peak Coincidence Factor is assumed to equal 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.

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Strip Curtain for Walk-in Coolers and Freezers (New Construction, Retrofit – New Equipment, Retrofit –Early Replacement)

Official Measure Code: CI-Refrig-StripCurt-1

Description

This commercial measure pertains to the installation of infiltration barriers (strip curtains) on walk-in coolers or freezers. Strip curtains impede heat transfer from adjacent warm and humid spaces into walk-ins when the main door is opened, thereby reducing the cooling load. As a result, compressor run time and energy consumption are reduced. The engineering assumption is that walk-in door is open 2.5 hours per day every day, and the strip curtain covers the entire door frame. Eligible applications include new construction and retrofit.

Definition of Efficient Equipment

The efficient equipment is a polyethylene strip curtain added to a walk-in cooler or freezer.

Definition of Baseline Equipment

The baseline assumption is a walk-in cooler or freezer that previously had either no strip curtain installed or an old, ineffective strip curtain installed.

Deemed Savings for this Measure

Annual kWh Savings[581]	= 2,974 for freezers = 422 for coolers
Summer Coincident Peak kW Savings	= 0.34 for freezers = 0.05 for coolers

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 6 years[582].

Deemed Measure Cost

The incremental capital cost for this measure is $10.22 per square foot of door opening (includes material and labor)[583].

581 Values based on analysis prepared by ADM for FirstEnergy utilities in Pennsylvania, provided via personal communication with Diane Rapp of FirstEnergy on June 4, 2010. Based on a review of deemed savings assumptions and methodologies from Oregon and California, the values from Pennsylvania appear reasonable and are the most applicable to the Indiana climate.

582 M. Goldberg, J. Ryan Barry, B. Dunn, M. Ackley, J. Robinson, and D. Deangelo-Woolsey, KEMA. "Focus on Energy: Business Programs – Measure Life Study", August 2009.

583 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is 100%[584].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = 2,974 for freezers
= 422 for coolers

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / 8760 * CF
= 0.35 for freezers
= 0.05 for coolers

Where:

8760 = hours per year
CF = Summer Peak Coincidence Factor for the measure
= 1.0

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[584] The summer coincident peak demand reduction is assumed as the total annual savings divided by the total number of hours per year, effectively assuming the average demand reduction is realized during the peak period. This is a reasonable assumption for refrigeration savings.

Door Gaskets for Refrigerated Cases

Official Measure Code: CI-Refrig-Gasket-1

Description

This section addresses savings from replacing worn-out gaskets with new better-fitting gaskets on glass or solid doors reach-in coolers and freezers. Tight-fitting gaskets inhibit infiltration of warm and moist air from the surrounding environment into the cold refrigerated space, thereby reducing the cooling load. They also prevent moisture from entering the refrigerated space ending up as frost on the cooling coils, reducing heat transfer effectiveness. As a result of these two factors, compressor run time and energy consumption are reduced.

Definition of Efficient Equipment

Replacement door gaskets applied to reach-in coolers and freezers.

Definition of Baseline Equipment

Reach-in cooler or freezer with worn gasket

Deemed Calculation for this Measure

Annual kWh Savings = 3.3 kWh/LF * LF (Freezers)
= 0.5 kWh/LF * LF (Coolers)

Summer Coincident Peak kW Savings = 0.34 W/LF * LF (Freezers)
= 0.05 W/LF * LF (Coolers)

Annual MMBtu Savings = 0

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 4 yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $2.25 per lineal foot.

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

The summer peak coincidence factor for this measure is 0.9.

REFERENCE SECTION

Calculation of Savings

Energy Savings

Annual kWh Savings = ΔkWh /LF

Where:

ΔkWh/LF = kWh savings per LF of gasket installed[585]
= 3.3 (reach-in freezers)
= 0.5 (reach-in coolers)

For example,

ΔkWh =

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / 8760 * CF

Where:

ΔkWh = annual kWh savings from gasket replacement

CF = Summer Peak Coincidence Factor for measure
= 0.9

For example,

ΔkW =

Fossil Fuel Impact Descriptions and Calculation
N/A

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

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Effective date: Date TRM will become effective
End date: TBD

Referenced Documents:

[585] Door gasket savings taken from a recent M&V study of door gasket replacements by ADM Associates in California. See Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation. Study ID PUC0016.01. California Public Utilities Commission. 2010.

Efficient Air Compressors (Time of Sale)

Official Measure Code: CI-Proc-AirComp-1

Description

This measure relates to the installation of an air compressor with a variable frequency drive, load/no load controls, or variable displacement controls. Baseline compressors choke off the inlet air to modulate the compressor output, which is not efficient. Efficient compressors use less energy at part load conditions. Demand curves are as per DOE data for a Variable Speed compressor versus a Modulating compressor. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new building (i.e. time of sale).

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be an air compressor with a variable frequency drive, load/no load controls[586], or variable displacement controls.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a modulating air compressor with blow down.

Deemed Calculation for this Measure

Annual kWh Savings $= BHP * 0.746 / \eta_{motor} \times HOURS \times ESF$

Summer Coincident Peak kW Savings $= \text{Annual kWh Savings} / HOURS * CF$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years [587].

Deemed Measure Cost

The incremental capital costs for this measure should be determined on a case-by-case basis. For analysis purposes, assume the incremental costs specified below:

[586] For analysis purposes, it is assumed that the compressed air system with load / no load controls utilizes an air receiver with a storage capacity of 5 gallons per cubic foot per minute of compressor capacity.
[587] Based on a review of TRM assumptions from Vermont, New Hampshire, Massachusetts, and Wisconsin. Estimates range from 10 to 15 years.

Compressor Type	Incremental Cost[588]
Load/No Load	$200/hp
Variable Displacement	$250/hp
Variable Frequency Drive	$300/hp

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 38%[589].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = BHP * 0.746 / η_{motor} x HOURS x ESF

Where:

BHP = compressor motor full load brake horse-power
= Actual installed
0.746 = conversion factor from horse-power to kW (kW/hp)
η_{motor} = compressor motor nameplate efficiency
= Actual installed (if actual efficiency in unknown, assume 90%[590])
HOURS = compressor total hours of operation
= Actual installed
ESF = Energy Savings Factor; dependent on compressor control type as below:

[588] Incremental cost estimates have been maintained from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009, and appear reasonable. However, future study of these estimates is recommended as published estimates of incremental costs for efficient air compressors are scarce. Costs do not include adding a receiver tank; it is assumed a receiver tank of adequate size is an existing part of the system.
[589] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.
[590] Improving Compressed Air System Performance: A Sourcebook for Industry, U.S. Department of Energy, November 2003.

Control Type	Energy Savings Factor (ESF)[591]
Load/No Load	10%
Variable Displacement	17%
Variable Frequency Drive	26%

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh / HOURS * CF

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.38 [592]

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
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[591] Energy Savings Factors were developed using U.S. Department of Energy part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors.

[592] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

Vending Machine Occupancy Sensors (Time of Sale, New Construction, Retrofit – New Equipment)

Official Measure Code: CI-Plug-Vending-1

Description

This measure relates to the installation of new controls on refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. Controls can significantly reduce the energy consumption of vending machine and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure relates to the installation of a new control on a new or existing unit. This measure should **not** be applied to ENERGY STAR qualified vending machines, as they already have built-in controls.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Deemed Calculation for this Measure

Annual kWh Savings = $8760 \times WATTS_{base} / 1000 \times ESF$

Summer Coincident Peak kW Savings = 0

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 5 years [593].

Deemed Measure Cost

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes[594]:

Refrigerated Vending Machine: $215.50
Non-Refrigerated Vending Machine: $108.00

[593] Measure Life Study, prepared for the Massachusetts Joint Utilities, Energy & Resource Solutions, November 2005.
[594] 2005 Database for Energy-Efficiency Resources (DEER), Version 2005.21. "Cost Data for Supporting Documents."

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 0[595].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = WATTS_{base} / 1000 * HOURS * ESF$$

Where:

$WATTS_{base}$ = connected kW of the controlled equipment; see table below for default values by connected equipment type:

Equipment Type	$WATTS_{base}$[596]
Refrigerated Beverage Vending Machines	400
Non-Refrigerated Snack Vending Machines	85
Glass Front Refrigerated Coolers	460

1000 = conversion factor (W/kW)

HOURS = operating hours of the connected equipment; assumed that the equipment operates 24 hours per day, 365 days per year = 8760

ESF = Energy Savings Factor; represents the percent reduction in annual kWh consumption of the equipment controlled; see table below for default values:

Equipment Type	Energy Savings Factor (ESF)[597]
Refrigerated Beverage Vending Machines	46%
Non-Refrigerated Snack Vending Machines	46%
Glass Front Refrigerated Coolers	30%

Summer Coincident Peak Demand Savings

ΔkW[598] = 0

[595] Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.
[596] USA Technologies Energy Management Product Sheets, July 2006; cited September 2009. <http:// http://www.usatech.com/energy_management/energy_productsheets.php>
[597] Ibid.
[598] Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

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Heat Pump Water Heaters (New Construction, Retrofit)

Official Measure Code: CI-SHW-HPWH-1

Description

This measure relates to the installation of a heat pump water heater (HPWH) in place of a standard electric water heater. HPWHs can be added to existing domestic hot water (DHW) systems to improve the overall efficiency. HPWHs utilize refrigerants (like an air source heat pump) and have much higher energy factors (EF) than standard electric water heaters. HPWHs remove waste heat from surrounding air sources and preheat the DHW supply system. HPWHs come in a variety of sizes and the size of HPWH will depend on the desired temperature output and amount of hot water needed by application. The savings from water heater heat pumps will depend on the design, size (capacity), water heating requirements, building application and climate. This measure could relate to either a retrofit or a new installation.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a heat pump water heater with or without an auxiliary water heating system.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline equipment is assumed to be a standard electric storage tank-type water heater. This measure does **not** apply to natural gas-fired water heaters.

Deemed Calculation for this Measure

Annual kWh Savings $= (GPD * 365 * 8.33 * \Delta T_s) / (3413\ ) * [(1/EF_{base}) - (1/\ EF_{ee})]$

Summer Peak Coincident kW Savings

$$= (GPH * 8.33 * \Delta T_s) / (3413) * [(1/EF_{base}) - (1/\ EF_{ee})] * CF$$

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 10 years[599].

Deemed Measure Cost

Due to the complexity of heat pump water heater systems, incremental capital costs should be determined on a case- by-case basis. High capacity heat pump water heaters will typically have a supplemental heating source such as an electric resistance heater. For new construction applications, the incremental capital cost for this measure should be calculated as the difference in installed cost of the entire heat pump water heater system including any auxiliary heating systems and a standard electric storage tank water heater of comparable capacity. For retrofit applications, the total installed cost of heat pump water heater should be used.

[599] Estimates of measure life from utilities in the Northeast and the U.S. Department of Energy vary from 10 to 15 years. Assume 10 years as a conservative estimate.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 6%[600].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWH = (GPD * 365 * 8.33 * \Delta T_s) / (3413) * [(1/EF_{base}) – (1/ EF_{ee})]$

Where:

GDP	= average daily hot water consumption (gallons/day); determined from site-specific data.
365	= conversion factor (days/year)
8.33	= conversion factor (Btu/gallon-°F)
ΔT_s	= average temperature difference between the supply cold water temperature and the hot water delivery temperature (°F); determined from site-specific data.
3413	= conversion factor (Btu/kWh)
EF_{base}	= baseline water heater Energy Factor; which is a function of the tank size = 0.93-0.00132V, where V is tank volume in gallons
EF_{ee}	= Energy Factor of the heat pump water heater system, = Actual installed

Summer Coincident Peak Demand Savings

$\Delta kW = (GPH * 8.33 * \Delta T_s) / (3413) * [(1/EF_{base}) – (1/ EF_{ee})] * CF$

Where:

GPH	= hourly hot water consumption (gallons/day); determined from site-specific data.
CF	= Summer Peak Coincidence Factor for measure = 0.06[601]

Fossil Fuel Impact Descriptions and Calculation

n/a[602]

[600] "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC," October 15, 2009. Based on Ohio utility supply profiles.
[601] "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE- UNC", October 15, 2009. Based on Ohio utility supply profiles.

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
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[602] The interactive effects between space heating and cooling requirements and heat pump water heaters have been neglected for this characterization but are candidates for future study. Heat pumps remove waste heat from surrounding air sources which can reduce cooling loads and increase heating loads if the heat pump water heater is located within a conditioned space.

Commercial Clothes Washer (Time of Sale)

Official Measure Code: CI-Proc-CloWash-1

Description

High-efficiency commercial washers are intended for purchase and installation in laundromats, multi-family buildings and institutions. These high-efficiency washers are nearly identical to residential models available in retail outlets, with minor engineering changes, such as the addition of a coin box. High-efficiency commercial washers typically save up to 50 percent of energy costs and use about 30 percent less water.

Definition of Efficient Equipment

The efficient equipment is defined as a commercial-grade clothes washer meeting the minimum efficiency standards for ENERGY STAR (MEF $\geq$1.8)[603]. Also, for this characterization to apply the facility where the equipment is installed must have an electric water heater.

Definition of Baseline Equipment

The baseline equipment for this measure is a commercial grade clothes washer that meets federal manufacturing standards (MEF $\geq$ 1.26).

Deemed Calculations for this Measure

Annual kWh Savings $= \Delta kWh_{Load} \times 950$

Summer Coincident Peak kW Savings = n/a

Deemed Lifetime of Efficient Equipment

The effective measure life for commercial-grade clothes washers is 10 years[604]

Deemed Measure Cost

$347 per unit ENERGY STAR/CEE Tier1, $475 per unit CEE Tier 2, $604 per unit CEE Tier 3[605]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

603 Beginning in 2011 the criteria will be raised to MEF > 2.0
604 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values",
605 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation",

REFERENCE SECTION

Calculation of Savings

Energy Savings

$\Delta kWh = \Delta kWh_{Load} \times Loads_{Year}$

Where:

ΔkWh_{Load} = The difference in electricity consumption per load of laundry between baseline equipment and efficient equipment
= Dependent on energy source for washer[606]:

Assumptions for Electricity and Gas Consumption for Commercial Clothes Washers

Fuel Source	ΔkWh per Load	Therms per Load
Electric Hot Water, Electric Dryer	0.57	0
Gas Hot Water, Electric Dryer	0.25	0.02

$Load_{Year}$ = Number of loads per year
= 950[607]

For example, a commercial clothes washer is installed in a facility with electric water heating and electric drying:

$\Delta kWh = 0.57 \times 950$

$= 541.5$ kWh

Summer Coincident Peak Demand Savings
No demand savings are claimed for this measure since there is insufficient peak coincident data.

Fossil Fuel Impact Descriptions and Calculation
Commercial clothes washers will only have fossil fuel impacts when either the washer, dryer, or both are powered by gas instead of electricity.

$\Delta MMBtu = \Delta MMBtu_{Load} \times Loads_{Year}$

[606] ENERGY STAR calculator for Commercial Clothes Washers, values based on the difference between the average of all qualified models and the average of all unqualified models (July 2009).
[607] ENERGY STAR calculator for Commercial Clothes Washers, Multi-Family Laundry Association (2002)

Where:

$\Delta MMBtu_{Load}$ = The difference in gas consumption per load of laundry between baseline equipment and efficient equipment
= Dependent on energy source for washer and dryer – see Table 'Assumptions for Electricity and Gas Consumption for Commercial Clothes Washers' above. Divide values in the table by 10 to convert from therms to MMBtu

$Loads_{Year}$ = Number of loads per year
= 950

Water Impact Descriptions and Calculation

The annual water savings for a commercial clothes washer is assumed to be 15,854 gallons per year.[608]

Deemed O&M Cost Adjustment Calculation

n/a

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Effective date: January 10, 2013
End date: TBD

[608] ENERGY STAR calculator for Commercial Clothes Washers, average water consumption based on all qualified models (July 2009)

Commercial Plug Load – Smart Strip Plug Outlets (Time of Use, Retrofit – New Equipment)

Official Measure Code: CI-Plug-Strip-1

Description

A smart strip plug outlet is a multi-plug power strip with the ability to automatically disconnect specific loads that are plugged into it depending upon the power draw of a control load, also plugged into the strip. The energy savings are measured by estimating the number of hours that electronic devices at typical workstations are either in the "sleep" mode or shut off and the standby loads consumed by the devices at those times. The smart strip will eliminate these standby loads and result in measureable energy savings. A smart strip plug outlet is purchased through a retail outlet and installed in an office environment where standby loads are uncontrolled.

Definition of Efficient Equipment

The efficient condition assumes peripherals electronic office equipment is plugged into the controlled Smart Strip outlets resulting in a reduction in standby load. No savings are associated with the control load, or loads plugged into the uncontrolled outlets.

Definition of Baseline Equipment

The baseline assumes a mix of typical office equipment (computer and peripherals) each with uncontrolled standby load.

Deemed Savings for this Measure

Annual kWh Savings = 23.6 kWh

Summer Coincident Peak kW Savings = 0

Deemed Lifetime of Efficient Equipment

The estimated useful life for a smart strip plug outlet is 8 years[609]

Deemed Measure Cost

The estimated incremental cost for smart strip plug outlets is assumed to be $15.[610]

Deemed O&M Cost Adjustments

n/a

[609] BC Hydro report: Smart Strip electrical savings and usability, October 2008 (unit can only take one surge, then needs to be replaced)

[610] Research Into Action, Inc. (2010) Electronics and Energy Efficiency: A Plug Load Characterization Study. Prepared for Southern California Edison.. Incremental cost over standard power strip with surge protection with average market price of $35 for controlled power strip and $20 for baseline plug strip with surge protection

Coincidence Factor

0[611]

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (WORKDAYS x $\Delta Wh_{Workday}$ + (365 – WORKDAYS) * $\Delta Wh_{Non\text{-}Workday}$)/ 1000

Where:

WORKDAYS	= Average number of workdays, or business days, in a year = 240[612]
$\Delta Wh_{workday}$	= The energy savings of devices plugged into the strip on work days (Wh) = 63.23 Wh[613]
$\Delta Wh_{Non\text{-}workday}$	= The energy savings of devices plugged into the strip on non-work days (Wh) = 67.63 Wh

Summer Coincident Peak Demand Savings

ΔkW = 0

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

611 Based on the assumption that most office equipment will be operating during the peak coincident hour
612 Assumes 2 weeks of vacation and 2 weeks of holidays for a total of 48 work weeks annually
613 See Table 'Standby Power Consumption of Devices Using Smart Strip Plug Outlets'

Reference Tables

Table 17. Standby Power Consumption for Devices Using Smart Strip Plug Outlets[614]

Plug Load	Watts in Standby	Hours in Standby	Watts when off	Hours Off, Workday	Hours Off, Non-Workday	% of strips[686]
LCD Monitor	1.38	4	1.13	12	24	69%
CRT Monitor	12.14	4	0.8	12	24	25%
Printer (avg. laser and ink)	NA	0	1.42	20	24	43%
Multifunction Printer (avg. laser and ink)	NA	0	4.19	20	24	12%
Speakers	1.79	4	1.79	12	24	1%
Scanner	NA	0	2.48	20	24	7%
Copier	NA	0	1.49	20	24	5%
Modem	3.85	16	3.84	0	24	8%
Charger	2.24	0	0.26	20	24	50%

$\Delta Wh_{Workday}$	63.2
$\Delta Wh_{Non\text{-}Workday}$	67.6

Version Date & Revision History

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[614] Standby and off loads sourced from Lawrence Berkeley National Laboratory http://standby.lbl.gov/summary-table.html. Hours of operation based on engineering estimates.

Plug Load Occupancy Sensor (Retrofit)

Official Measure Code: CI-Plug-OccSens-1

Description

Plug load occupancy sensors are devices that control low wattage office equipment using an occupancy sensor. They typically use an infrared sensor to monitor movement, and use a smart strip to turn off connected devices, or put them in standby mode, when no one is present.

Definition of Efficient Equipment

In order for this characterization to apply, the installed equipment must be a 'smart' power strip with both control and peripheral outlets, and an occupancy sensor.

Definition of Baseline Equipment

The baseline assumes a mix of typical document station office equipment (printers, scanners, fax machines, etc.) each with uncontrolled standby load.

Deemed Savings for this Measure

Annual kWh Savings = 169 kWh/yr

Summer Coincident Peak kW Savings = 0

Deemed Lifetime of Efficient Equipment

The estimated useful life for a smart strip plug outlet is 8 years[615]

Deemed Measure Cost

The incremental cost for this measure is assumed to be $70[616]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

0[617]

REFERENCE SECTION

[615] BC Hydro report: Smart Strip electrical savings and usability, October 2008 (unit can only take one surge, then needs to be replaced)

[616] Plug Load Characterization Study for Southern California Edison. Prepared by Research Into Action (2010)

[617] Based on assumption that office equipment will be running during the peak period

Calculation of Savings

Energy Savings

$\Delta kWh = (WORKDAYS \times \Delta Wh_{sleep}) / 1000$

Where:

WORKDAYS = Average number of workdays, or business days, in a year
= 240[618]

ΔWh_{sleep} = The energy savings of devices plugged into the strip when in 'sleep' mode (Wh)
= 704[619]

Summer Coincident Peak Demand Savings

$\Delta kW = 0$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables

Table 18. Standby Power Consumption for Devices Using Smart Strip Plug Outlets[620] (All values in Watts)

Computer Peripherals	Connected Load when 'On'	Connected Load in 'Sleep'	Hours in Sleep Mode	Daily Savings
Laser Printer	131	2	4	516
Multi-function device, laser (scanner, fax)	50	3	4	188
			Total	704

[618] Assumes 2 weeks of vacation and 2 weeks of holidays for a total of 48 work weeks annually
[619] See Table 'Standby Power Consumption of Devices Using Smart Strip Plug Outlets'
[620] Standby loads sourced from Lawrence Berkeley National Laboratory http://standby.lbl.gov/summary-table.html. Hours of operation based on engineering estimations.

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Energy Efficient Furnace (Time of Sale, Retrofit – Early Replacement)

Official Measure Code: CI-HVAC-Furnace-1

Description

This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace. High efficiency gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, most of the flue gasses condense and must be drained. Furnaces equipped with ECM fan motors can save additional electric energy.

Definition of Efficient Equipment

The efficient equipment is a natural gas-fired furnace with a minimum Annual Fuel Utilization Efficiency (AFUE) rating of 93%.

Definition of Baseline Equipment

The equivalent baseline equipment is a natural gas-fired furnace with an AFUE of 80%.

Deemed Calculation for this Measure

Annual kWh Savings $= 5 \times CAP \times EFLH_h \times (\eta_{base}/\eta_{ee})$

Summer Coincident Peak kW Savings $= 0$[621]

Annual MMBtu Savings $= (CAP) * (EFLH_h) * ((1 - (\eta_{base}/\eta_{ee})) - MMBtu_{ECM}$

Deemed Lifetime of Efficient Equipment

20[622]

Deemed Measure Cost

Incremental cost estimated at $900[623]

Deemed O&M Cost Adjustments

$0[624]

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621 For analysis purposes, it is assumed that the furnace fan does not operate during the summer season and therefore contributes no summer peak coincident savings.

622 Based on engineering modeling by Michael Blasnik (M. Blasnik & Associates) and KEMA in support of “Application of Columbia Gas of Ohio, Inc, to Establish Demand Side Management Programs for Residential and Commercial Consumers,” Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008

623 Ibid.

624 Ibid.

Coincidence Factor

n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings

If furnace equipped with ECM fan motors, the following algorithm can be used to calculate energy savings; otherwise, electric energy savings are zero:

$$\Delta kWh = (5) \times (CAP) \times (EFLH_h) \times (\eta_{base}/\eta_{ee})$$

Where:

5 = annual kWh savings per MMBtu of heating fuel consumption[625]
CAP = equipment heating input capacity (MMBtu/hr)
$EFLH_h$ = equivalent full load heating hours from Table below:

	Heating EFLH				
Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

η_{ee} = installed equipment efficiency; expressed as AFUE, Combustion Efficiency (E_c), or Thermal Efficiency (E_t).

[625] Adapted from "Electricity Use by New Furnaces: A Wisconsin Field Study," Energy Center of Wisconsin, 10/2003. Assumes ECM fan motor savings scale linearly with annual fuel consumption.

η_{base} = Assume 80%[626].

Summer Coincident Peak Demand Savings

ΔkW = 0

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu$ = $(CAP) * (EFLH_h) * (\eta_{ee}/\eta_{base} - 1) - MMBtu_{ECM}$

Where:

$MMBtu_{ECM}$ = increased heating fuel consumption in MMBtu due to decreased fan motor waste heat (for furnaces with ECM fan ONLY)
= $(0.019) * (CAP) * (EFLH_h) * (\eta_{base}/\eta_{ee})$[627]

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[626] ASHRAE 90.1-2007 Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements. Dependent on equipment type and capacity, minimum efficiency levels range from 78% to 81% and are either expressed as AFUE, Ec, or Et. For analysis purposes, assume 80%.

[627] Adapted from "Electricity Use by New Furnaces: A Wisconsin Field Study," Energy Center of Wisconsin, 10/2003.

High Efficiency Storage Tank Water Heater (Time of Sale, Retrofit – Early Replacement)

Official Measure Code: CI-SHW-StorWH-1

Description

Stand-alone, or tank-type heaters, run off natural gas. These water heaters consist of a storage tank with an attached heat source, in this case, a high-efficiency gas burner. They achieve energy savings through the use of efficient heating equipment and superior tank insulation.

Definition of Efficient Equipment

The efficient case is a natural gas-fired tank-type water heater exceeding the efficiency requirements as mandated ASHRAE 90.1-2007.

Definition of Baseline Equipment

The baseline condition is a gas-fired tank-type water heater meeting the efficiency requirements as mandated by ASHRAE 90.1-2007.

Deemed Savings for this Measure

Annual kWh Savings = 0

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings $= [W \times 8.33 \times (T_{out}-T_{in}) \times ((1/\eta_{base})-(1/\eta_{ee})) + (STBY_{base} - STBY_{ee}) \times 8760] / 1{,}000{,}000$

Deemed Lifetime of Efficient Equipment

12 years[628]

Deemed Measure Cost

$300[629]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

[628] Ibid.
[629] Ibid.

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = [W \times 8.33 \times (T_{out}-T_{in}) \times ((1/\eta_{base})-(1/\eta_{ee})) + (STBY_{base} - STBY_{ee}) \times 8760] / 1{,}000{,}000$$

Where:

W = Annual water use for equipment (in gallons). See Table in Reference section.

8.33 = weight in lbs of 1 gallon of water, or the Btus required to raise 1 gallon of water 1 ºF

T_{out} = water heater set point (ºF)
= If unknown, assume 130 ºF[630]

T_{in} = water inlet temperature (ºF)

Cold water entering temperatures vary according to climate. Ground water temperature is approximately equal to the annual average temperature, while surface water temperature is approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

City	Groundwater Temperature (°F)	Surface Water Temperature (°F)
Indianapolis	51.9	57.9
South Bend	51.2	57.2
Terre Haute	54.3	60.3
Evansville	56.6	62.6
Ft Wayne	49.5	55.5

η_{base} = rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (E); see table below for values:

630 NAHB Research Center, (2002). Performance Comparison of Residential Hot Water Systems. Prepared for: National Renewable Energy Laboratory, Golden, Colorado.

Equipment Type	Size Category (Input)	Subcategory	Performance Required[631] (η_{base} and $STBY_{base}$)
Storage water heaters, Gas	<= 75,000 Btu/h	>= 20 gal	EF = 0.67 - 0.0019V
	> 75,000 Btu/h and <= 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base}$ = (Q / 800 + 110√V)
	> 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base}$ = (Q / 800 + 110√V)

V = rated tank volume in gallons
= Actual installed

Q = nameplate input rate in Btu/hr
= Actual installed

η_{ee} = rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (E)
= Actual installed

$STBY_{base}$ = standby losses/hr of baseline water heater (Btu/hr); see table above for values.

$STBY_{ee}$ = standby losses/hr of efficient water heater (Btu/hr)
= Actual installed (for unit rated with Energy Factor (EF), $STBY_{base}$ = 0)

8760 = hours per year

1,000,000 = conversion factor (Btu/MMBtu)

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[631] ASHRAE 90.1-2007 Minimum Performance of Water-Heating Equipment.

Reference Tables

Proposed Deemed Values for Gallons of Hot Water Use per Day (GPD) by Buillding Type

Building Type	GPD	Rate	Notes	Source
Assembly	150	5 per seat	water not HOT water; assume 10% hot water, 300 seats	http://www.p2pays.org/ref/42/41980.pdf
Big Box	100		assume like Small Office	Staff estimate
Fast Food	630	0.7 GPD per meal	50 meals per hour, 18 hours per day	NY TRM
Full Service Restaurant	1152	2.4 GPD per meal	40 meals per hour, 12 hr per day	NY TRM
Grocery	200		assume 2x Big Box	Staff estimate
Hospital	12000	300 GDP per bed	water not HOT water; assume 50% hot water, 80 beds	http://www.p2pays.org/ref/42/41980.pdf
Large Office	500	1.0 GDP per person	assume 500 ppl	NY TRM
Light Industrial	1250	25 GPD per person per shift	water not HOT water; assume half hot water, 100 people/day	http://www.p2pays.org/ref/42/41980.pdf
Multifamily high-rise	920	46 GPD per unit	20 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/0	NY TRM
Multifamily low-rise	276	46 GPD per unit	6 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/09	NY TRM
Primary School	300	0.6 GPD per student	500 students; reduce days per year to reflect school calendar	NY TRM
Small Office	100	1.0 GPD per person	100 people	NY TRM
Small Retail	50		Half of Big Box	Staff estimate
Auto repair	29		1-person household	Staff estimate
Community College	1440		assume like Secondary School	Staff estimate
Dormitory	14700		Single-person household - 500 students	Staff estimate
Heavy Industrial	1250	25 GPD per person per shift	water not HOT water; assume half hot water, 100 people/day	http://www.p2pays.org/ref/42/41980.pdf
Hotel	9000		3/4 of hotel	Staff estimate
Industrial Refrigeration	29		Assume like Auto Repair	Staff estimate
Motel	4500		Assume half of Hotel - laundry done on site	Staff estimate
Multi Story Retail	75		1.5* Small Retail	Staff estimate
Religious	150		Assume like Assembly	Staff estimate
Secondary School	1440	1.8 GPD per student	800 students; reduce days per year to reflect school calendar	NY TRM
University	3450	69 GPD per student	water not HOT water; assume 10% hot water, 500 students	http://www.p2pays.org/ref/42/41980.pdf
Warehouse	100		assume like Small Office	Staff estimate

Tankless Water Heaters (Time of Sale, Retrofit – Early Replacement)

Official Measure Code: CI-SHW-TanklessWH-1

Description

This measure covers the installation of a natural gas-fired tankless or instantaneous water heater. Tankless water heaters essentially function like normal water heaters without the storage tank. When there is demand for hot water, the gas burner fires and heats water as it passes through the heater to the demand source. Because the water heater must heat water at the rate of flow through the device, tankless water heaters are not well suited to serve sources of significant demand. Tankless water heaters achieve savings by eliminating the standby losses that occur in stand- alone or tank-type water heaters.

Definition of Efficient Equipment

The efficient case is a tankless natural gas-fired water heater exceeding the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 504.2.

Definition of Baseline Equipment

The baseline condition is a gas-fired tank-type water heater meeting the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 504.2.

Deemed Calculation for this Measure

Annual kWh Savings = 0

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings $= W \times 8.33 \times (T_{out}-T_{in}) \times [(1/\eta_{base}) - (1/\eta_{ee})] + (STBY_{base} \times 8760) / 1{,}000{,}000$

Deemed Lifetime of Efficient Equipment

20 years[632]

Deemed Measure Cost [633]
Full Installed Cost: $871.74
Incremental Material Cost: $433.72

[632] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report
[633] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008

Deemed O&M Cost Adjustments

$9.60[634]

Coincidence Factor

n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = W \times 8.33 \times (T_{out} - T_{in}) \times [(1/\eta_{base}) - (1/\eta_{ee})] + (STBY_{base} \times 8760) / 1{,}000{,}000$$

Where:

W = Annual water use for equipment (in gallons). See Reference Tables below.
= Gallons per day (GPD) x day/yr

8.33 = weight in lbs of 1 gallon of water, or the Btus required to raise 1 gallon of water 1 ºF

T_{out} = water heater set point (ºF) (demand temperature)
= If unknown, assume 130 ºF[635]

T_{in} = water inlet temperature (ºF)

Cold water entering temperatures vary according to climate. Ground water temperature is approximately equal to the annual average temperature, while surface water temperature is approximately equal to the annual average outdoor temperature plus 6°F. Water temperature is usually monitored by the water utility, and is available on request. Cold water entering temperatures based on the annual outdoor temperature are shown below.

[634] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report
[635] NAHB Research Center, (2002). Performance Comparison of Residential Hot Water Systems. Prepared for: National Renewable Energy Laboratory, Golden, Colorado.

City	Groundwater Temperature (°F)	Surface Water Temperature (°F)
Indianapolis	51.9	57.9
South Bend	51.2	57.2
Terre Haute	54.3	60.3
Evansville	56.6	62.6
Ft Wayne	49.5	55.5

η_{base} = rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (E); see table below for values:

Equipment Type	Size Category (Input)	Subcategory	Performance Required[636] (η_{base} and $STBY_{base}$)
Storage water heaters, Gas	<= 75,000 Btu/h	>= 20 gal	EF = 0.67 - 0.0019V
	> 75,000 Btu/h and <= 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base}$ = (Q / 800 + 110√V)
	> 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base}$ = (Q / 800 + 110√V)

V = rated tank volume in gallons
= Actual installed

Q = nameplate input rate in Btu/hr
= Actual installed

η_{ee} = rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (E)
= Actual installed

1,000,000 = conversion factor (Btu/MMBtu)

$STBY_{base}$ = standby losses/hr of baseline water heater (Btu/hr); see table above for values.

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

636 ASHRAE 90.1-2007 Minimum Performance of Water-Heating Equipment.

Reference Tables

Proposed Deemed Values for Gallons of Hot Water Use per Day (GPD) by Buillding Type

Building Type	GPD	Rate	Notes	Source
Assembly	150	5 per seat	water not HOT water; assume 10% hot water, 300 seats	http://www.p2pays.org/ref/42/41980.pdf
Big Box	100		assume like Small Office	Staff estimate
Fast Food	630	0.7 GPD per meal	50 meals per hour, 18 hours per day	NY TRM
Full Service Restaurant	1152	2.4 GPD per meal	40 meals per hour, 12 hr per day	NY TRM
Grocery	200		assume 2x Big Box	Staff estimate
Hospital	12000	300 GDP per bed	water not HOT water; assume 50% hot water, 80 beds	http://www.p2pays.org/ref/42/41980.pdf
Large Office	500	1.0 GDP per person	assume 500 ppl	NY TRM
Light Industrial	1250	25 GPD per person per shift	water not HOT water; assume half hot water, 100 people/day	http://www.p2pays.org/ref/42/41980.pdf
Multifamily high-rise	920	46 GPD per unit	20 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/(	NY TRM
Multifamily low-rise	276	46 GPD per unit	6 units, (2 ppl per unit, ref table on page 66 of SF manual 12/16/09	NY TRM
Primary School	300	0.6 GPD per student	500 students; reduce days per year to reflect school calendar	NY TRM
Small Office	100	1.0 GPD per person	100 people	NY TRM
Small Retail	50		Half of Big Box	Staff estimate
Auto repair	29		1-person household	Staff estimate
Community College	1440		assume like Secondary School	Staff estimate
Dormitory	14700		Single-person household - 500 students	Staff estimate
Heavy Industrial	1250	25 GPD per person per shift	water not HOT water; assume half hot water, 100 people/day	http://www.p2pays.org/ref/42/41980.pdf
Hotel	9000		3/4 of hotel	Staff estimate
Industrial Refrigeration	29		Assume like Auto Repair	Staff estimate
Motel	4500		Assume half of Hotel - laundry done on site	Staff estimate
Multi Story Retail	75		1.5* Small Retail	Staff estimate
Religious	150		Assume like Assembly	Staff estimate
Secondary School	1440	1.8 GPD per student	800 students; reduce days per year to reflect school calendar	NY TRM
University	3450	69 GPD per student	water not HOT water; assume 10% hot water, 500 students	http://www.p2pays.org/ref/42/41980.pdf
Warehouse	100		assume like Small Office	Staff estimate

Stack Damper (Retrofit – New Equipment)

Official Measure Code: CI-HVAC-StackDamp-1

Description

This measure covers the installation of a servo-controlled, exhaust vent stack damper on a boiler. The vent damper should be installed in the flue pipe, between the heating equipment and the chimney. A stack damper works like a flue damper on a fireplace by reducing draft, improving comfort, and minimizing heat loss. The vent damper can either be controlled by a heat sensor installed directly in the vent stack or by a mechanical switch connected to the thermostat, which is wired to work in unison with the ignition control switch on the boiler.

In combustion appliances that are directly vented to the atmosphere, there is a decrease in operating efficiency during standby, start-up and shut-down. During these times, warm room air is drawn through the stack via the draft hood or dilution air inlet at a rate proportional to the stack height, diameter and outdoor temperature. The most air is drawn through the vent immediately after the appliance shuts off and the flue is still hot. A vent damper can prevent residual heat from being drawn up the warm vent stack by closing itself. Vent dampers can also reduce the amount of air that passes through the furnace or boiler heat exchanger by regulating start-up exhaust pressure, which can increase operating efficiency by reducing the time needed to achieve steady- state operating conditions. Lastly, by reducing air infiltration in the building, vent dampers can help to retain humidity, which can improve comfort during periods of high heating degree days.

Definition of Efficient Equipment

The efficient equipment is a vent stack with a damper installed.

Definition of Baseline Equipment

The baseline condition is a vent stack with no stack damper installed.

Deemed Calculation for this Measure

Annual kWh Savings = n/a

Summer Coincident Peak kW Savings = n/a

Annual MMBtu Savings = 100 MMBtu[637]

[637] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report. Based on information published by Natural Resources Canada and the Minneapolis Energy Office, savings estimates for stack dampers range from to 0 to 9.5% of total boiler gas consumption. This implies that the boiler capacity assumed to determine the deemed savings value is quite large and may overstate savings for smaller boilers. If significant participation for this measure is realized, it is suggested that the deemed savings estimate be abandoned in favor of a deemed calculated approach.

Deemed Lifetime of Efficient Equipment

12 yrs[638]

Deemed Measure Cost

$150[639]

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Baseline Adjustment
n/a

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = 100 \text{ MMBtu}$$

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[638] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report
[639] Manufacturer research suggests a range of $80-$200 materials cost, depending on size, safety controls and motor quality, as well as 1-2 hours average install time.

Natural Gas-Fired Infrared Heater (Time of Sale)

Official Measure Code: CI-HVAC-IRHeater-1

Description

This measure covers the installation of a natural gas-fired infrared heater.

Definition of Efficient Equipment

An infrared heater heats primarily through radiation and conduction, as opposed to traditional forced-air space heaters which heat through convection. Infrared heaters are able to heat more efficiently because they directly heat the objects in the space, including the floor slab, which then radiate heat into the air space. With a forced hot air system, the heated air rises to the ceiling and stratifies, gradually working its way down to the floor level. The floor slab and equipment act as heat sinks causing the ceiling level to be much warmer than the floor area, which will cause the forced air system to work much harder to heat the same space. What is more, forced-air systems can experience drastic losses of heated air to ventilation air changes. There is also a negligible amount of electricity use (burner ignition and gas valve) compared to a forced-air system which requires large fans to move air around the conditioned space.

Definition of Baseline Equipment

The baseline equipment is a standard natural gas-fired convection space heater.

Deemed Calculation for this Measure

Annual kWh Savings	= n/a
Summer Coincident Peak kW Savings	= n/a
Annual MMBtu Savings	= 11.4 MMBtu/year[640]

Deemed Lifetime of Efficient Equipment

15 yrs[641]

Deemed Measure Cost

$920 (incremental cost)[642]

[640] Based on engineering modeling by GSE in support of "Application of Columbia Gas of Ohio, Inc, to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008. A review of savings assumptions used in Massachusetts indicates that this estimate is very conservative. The proposed value is only 85% of what is assumed for Massachusetts and should be considered for future study if this measure receives significant participation.
[641] Ibid.
[642] Ibid.

Deemed O&M Cost Adjustments

n/a

Coincidence Factor

n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Baseline Adjustment
n/a

Fossil Fuel Impact Descriptions and Calculation

$$\Delta \text{MMBtu} \quad = 11.4 \text{ MMBtu/year}$$

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

Energy Efficient Boiler (Time of Sale)

Official Measure Code: CI-HVAC-Boiler-1

Description

This measure covers the replacement of an irreparable existing boiler with a high efficiency, gas-fired steam or hot water boiler. High efficiency boilers achieve gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

Definition of Efficient Equipment

The efficient equipment is a natural gas-fired hot water or steam boiler exceeding the efficiency requirements as mandated by ASHRAE 90.1-2007.

Definition of Baseline Equipment

The baseline equipment is a natural gas-fired boiler meeting the efficiency requirements as mandated by ASHRAE 90.1-2007.

Deemed Calculation for this Measure

Annual kWh Savings = 0

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings = $(CAP) \times (EFLH_h) \times ((\eta_{ee}/\eta_{base})-1)$

Deemed Lifetime of Efficient Equipment

20 years[643]

Deemed Measure Cost

Incremental cost is estimated at $5,000[644]

Deemed O&M Cost Adjustments

$0[645]

Coincidence Factor

n/a

643 Based on engineering modeling by Michael Blasnik (M. Blasnik & Associates) in support of "Application of Columbia Gas of Ohio, Inc, to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008
644 Ibid.
645 Ibid.

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

Annual MMBtu Savings = (CAP) x ($EFLH_h$) x ((η_{ee}/η_{base})-1)

Where:

CAP = equipment heating input capacity (MMBtu/hr)
= Actual installed
$EFLH_h$ = equivalent full load heating hours; determined with site-specific data. If actual value is unknown, select value from Table in Reference section.
η_{ee} = installed equipment efficiency; expressed as AFUE, Combustion Efficiency (E_c), or Thermal Efficiency (E_t).
= Actual installed
η_{base} = baseline equipment efficiency; expressed as AFUE, E_c, or E_t; see table below for values:

Equipment Type	Size Category (Input)	Subcategory Or Rating Condition	Minimum Efficiency[646]
Boilers, Gas fired	< 300,000 Btu/h	Hot water	80% AFUE
		Steam	75% AFUE
	>= 300,000 Btu/h and <= 2,500,000 Btu/h	Minimum capacity	75% E_t
	>2,500,000 Btu/h	Hot water	80% E_c
		Steam	80% E_c

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Effective date: January 10, 2013
End date: TBD

[646] ASHRAE 90.1-2007 Boilers, Gas- and Oil-Fired, Minimum Efficiency Requirements

Reference Tables

Small Commercial Building Heating EFLH

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

Large Commercial Building Heating EFLH

Building Type	System	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
	CAV no econ	703	697	585	703	782
	CAV econ	877	898	784	877	958
Hotel	VAV econ	401	367	229	401	437
	CAV no econ	2,627	2,066	1,785	2,543	2,389
	CAV econ	2,566	2,087	1,761	2,526	2,328
Large Office	VAV econ	531	333	294	538	386
	CAV no econ	3,503	3,073	3,476	3,227	3,005
	CAV econ	3,713	3,359	3,625	3,504	3,367
Hospital	VAV econ	604	604	363	613	302

Commercial Boiler Tune-Up

Official Measure Code: CI-HVAC-BoilerTune-1

Description

This section covers tune-ups of existing commercial boilers to improve the seasonal heating efficiency.

Definition of Efficient Equipment

Boiler after tune-up is performed

Definition of Baseline Equipment

Existing boiler before tune-up is performed

Deemed Calculation for this Measure

Annual MMBtu Savings = (CAP) x ($EFLH_h$) x 0.02

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 5 yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $850[647] per boiler tune-up

Deemed O&M Cost Adjustments

NA

Coincidence Factor

N/A

REFERENCE SECTION

Calculation of Savings

Fossil Fuel Impact Descriptions and Calculation

Annual MMBtu Savings = (CAP) x ($EFLH_h$) x ESF

[647] Tune-up costs for commercial boilers in Michigan Efficiency Measures Database.

Where:

CAP = equipment heating input capacity (MMBtu/hr)
= Actual installed
$EFLH_h$ = equivalent full load heating hours; determined with site-specific data. If actual value is unknown, select value from Table in Reference section.
ESF = energy savings factor
= 0.02[648]

For example, a tune-up of a 3,000,000 Btu/hr boiler serving a large office with a VAV system in Indianapolis:

$$\text{Annual MMBtu Savings} = (CAP) \times (EFLH_h) \times ESF \times 10^{-6}$$
$$= 3{,}000{,}000 \times 531 \times 0.02 \times 10^{-6}$$
$$= 31.9 \text{ MMBtu}$$

Water Impact Description and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Version Date & Revision History

Effective date: Date TRM will become effective
End date: TBD

[648] Energy savings on the order of 2% for commercial boiler tuneups are used in the Michigan Efficiency Measures Database.

Reference Tables

Small Commercial Building Heating EFLH

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

Large Commercial Building Heating EFLH

Building Type	System	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Hotel	CAV no econ	703	697	585	703	782
	CAV econ	877	898	784	877	958
	VAV econ	401	367	229	401	437
Large Office	CAV no econ	2,627	2,066	1,785	2,543	2,389
	CAV econ	2,566	2,087	1,761	2,526	2,328
	VAV econ	531	333	294	538	386
Hospital	CAV no econ	3,503	3,073	3,476	3,227	3,005
	CAV econ	3,713	3,359	3,625	3,504	3,367
	VAV econ	604	604	363	613	302

Boiler Combustion Controls

Official Measure Code: CI-HVAC-BlrCombCtrl-1

Description

This section covers an oxygen trim control measure for a commercial boiler. A 1.1% improvement[649] in boiler efficiency resulting from the addition of oxygen trim controls is assumed.

Definition of Efficient Equipment

Existing boiler with oxygen trim controller installed

Definition of Baseline Equipment

Existing boiler without oxygen trim controls.

Deemed Calculation for this Measure

Annual MMBtu Savings = (CAP) x ($EFLH_h$) x 0.011 x 10^{-6}

Deemed Lifetime of Efficient Equipment

The expected lifetime of the measure is 10 yr.

Deemed Measure Cost

The incremental cost for this measure is assumed to be $0.85 per kBtuh of boiler output.

Deemed O&M Cost Adjustments

N/A

Coincidence Factor

N/A

REFERENCE SECTION

Calculation of Savings

Fossil Fuel Impact Descriptions and Calculation

Annual MMBtu Savings = (CAP) x ($EFLH_h$) x ESF x 10^{-6}

[649] Oxygen trim control savings taken from Michigan Boiler Oxygen Trim Control Workpaper, prepared by Franklin Energy Services for the Michigan Efficiency Measures Database.

Where:

CAP = equipment heating input capacity (MMBtu/hr)
= Actual installed
$EFLH_h$ = equivalent full load heating hours; determined with site-specific data. If actual value is unknown, select value from Table in Reference section.
ESF = energy savings factor
= 0.011

For example, combustion controls applied to a 3,000,000 Btu/hr boiler serving a large office with a VAV system in Indianapolis:

$$\text{Annual MMBtu Savings} = (CAP) \times (EFLH_h) \times ESF \times 10^{-6}$$
$$= 3{,}000{,}000 \times 531 \times 0.011 \times 10^{-6}$$
$$= 17.5 \text{ MMBtu}$$

Water Impact Description and Calculation
N/A

Deemed O&M Cost Adjustment Calculation
N/A

Version Date & Revision History

Effective date: Date TRM will become effective
End date: TBD

Reference Tables

Small Commercial Building Heating EFLH

Building	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Assembly	874	954	611	1,009	659
Auto Repair	3,319	3,930	2,582	3,299	2,918
Big Box Retail	519	538	325	607	367
Fast Food Restaurant	1,253	1,383	824	1,463	907
Full Service Restaurant	1,164	1,396	768	1,441	893
Grocery	519	538	325	607	367
Light Industrial	1,113	1,205	718	1,289	775
Primary School	1,192	1,266	785	1,359	845
Religious Worship	923	1,070	677	1,085	779
Small Office	670	710	487	826	526
Small Retail	939	977	591	1,125	661
Warehouse	1,113	1,205	718	1,289	775
Other	1,133	1,264	784	1,283	873

Large Commercial Building Heating EFLH

Building Type	System	Indianapolis	South Bend	Evansville	Ft Wayne	Terre Haute
Hotel	CAV no econ	703	697	585	703	782
	CAV econ	877	898	784	877	958
	VAV econ	401	367	229	401	437
Large Office	CAV no econ	2,627	2,066	1,785	2,543	2,389
	CAV econ	2,566	2,087	1,761	2,526	2,328
	VAV econ	531	333	294	538	386
Hospital	CAV no econ	3,503	3,073	3,476	3,227	3,005
	CAV econ	3,713	3,359	3,625	3,504	3,367
	VAV econ	604	604	363	613	302

IV. Appendices

Appendix A – Prototypical Building Energy Simulation Model Development

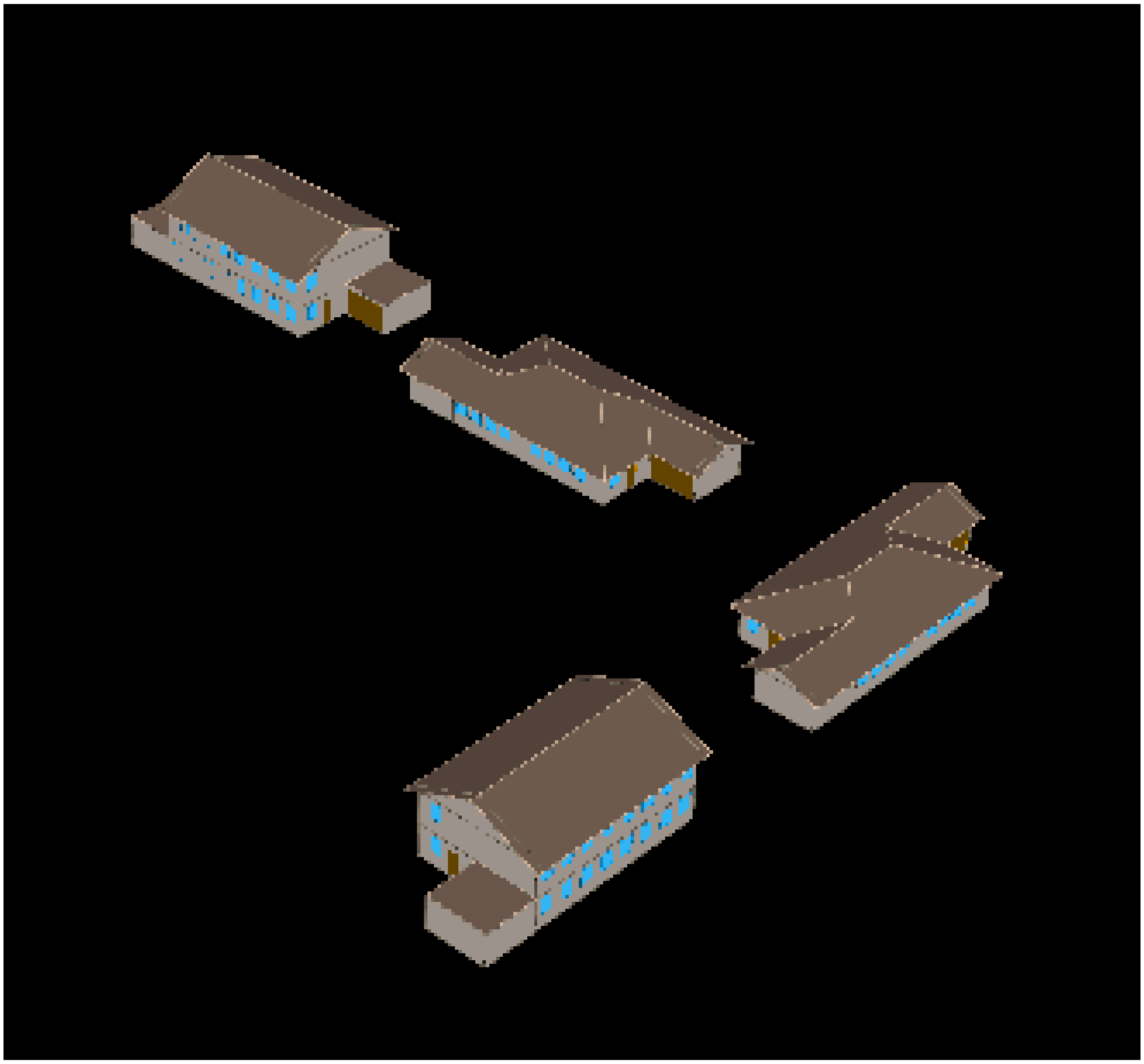
Many of the savings values from the TRM are derived from DOE-2.2 simulations of typical commercial buildings. They are based on building prototypes originally developed to calculate savings for California's Database for Energy Efficient Resources (DEER), with certain parameters adjusted to Indiana building practice based on a review of the U.S. Energy Information Administration's (EIA) Commercial Buildings Energy Consumption Survey (CBECS). The following sections provide a description of the prototypical buildings and a summary of key modeling assumptions.

Residential Building Prototypes

Analysis used to develop parameters for the energy and demand savings calculations are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER)[650] study, with adjustments made for local building practices and climate. The single family "model" in fact contains 4 separate residential buildings: 2 one-story and 2 two-story buildings. Each version of the 1 story and 2 story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these 4 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures.

A sketch of the single family residential prototype buildings is shown below.

[650] 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report, Itron, Inc. Vancouver, WA. December, 2005. Available at http://www.calmac.org/publications/2004-05_DEER_Update_Final_Report-Wo.pdf



Computer rendering of single family residential building prototypical DOE-2 model.

The general characteristics of the single family residential building prototype model are summarized below.

Single Family Residential Building Prototype Description

Characteristic	Value
Conditioned floor area	1 story house: 1465 SF (not including basement) 2 story house: 2930 SF (not including basement)
Wall construction	Wood frame with siding
Roof construction	Wood frame with asphalt shingles
Glazing type	Double pane clear
Lighting and appliance power density	0.51 W/SF average
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% over-sizing.
HVAC system efficiency	Baseline SEER = 13
Thermostat setpoints	Heating: 70°F with setback to 67°F Cooling: 75°F with setup to 78°F
Duct location	Buildings without basement: attic Buildings with basement: basement
Duct surface area	Single story house: 390 SF supply, 72 SF return Two story house: 505 SF supply, 290 SF return
Duct insulation	Uninsulated
Duct leakage	20% of fan flow total leakage, evenly split between supply and return.
Natural ventilation	Allowed during cooling season when cooling setpoint exceeded and outdoor temperature < 65°F. 3 air changes per hour

Commercial Building Prototype Model Development

Commercial sector prototype building models were developed for a series of small commercial buildings with packaged rooftop HVAC systems, including assembly, big box retail, fast food restaurant, full service restaurant, grocery, light industrial, primary school, small office and small retail buildings. Large office, hotel and hospital prototypes were also included to analyze measures associated with built-up HVAC systems. The following sections describe the prototypical simulation models used in this analysis.

Assembly

A prototypical building energy simulation model for an assembly building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 19.

Table 19. Assembly Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	34,000 square feet Auditorium: 33,240 SF Office: 760 SF
Number of floors	1
Wall construction and R-value	Concrete block, R-5
Roof construction and R-value	Wood frame with built-up roof, R-12
Glazing type	Multipane Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Auditorium: 1.9 W/SF Office: 1.55 W/SF
Plug load density	Auditorium: 1.2 W/SF Office: 1.7 W/SF
Operating hours	Mon-Sun: 8am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the prototype is shown in Figure 2.

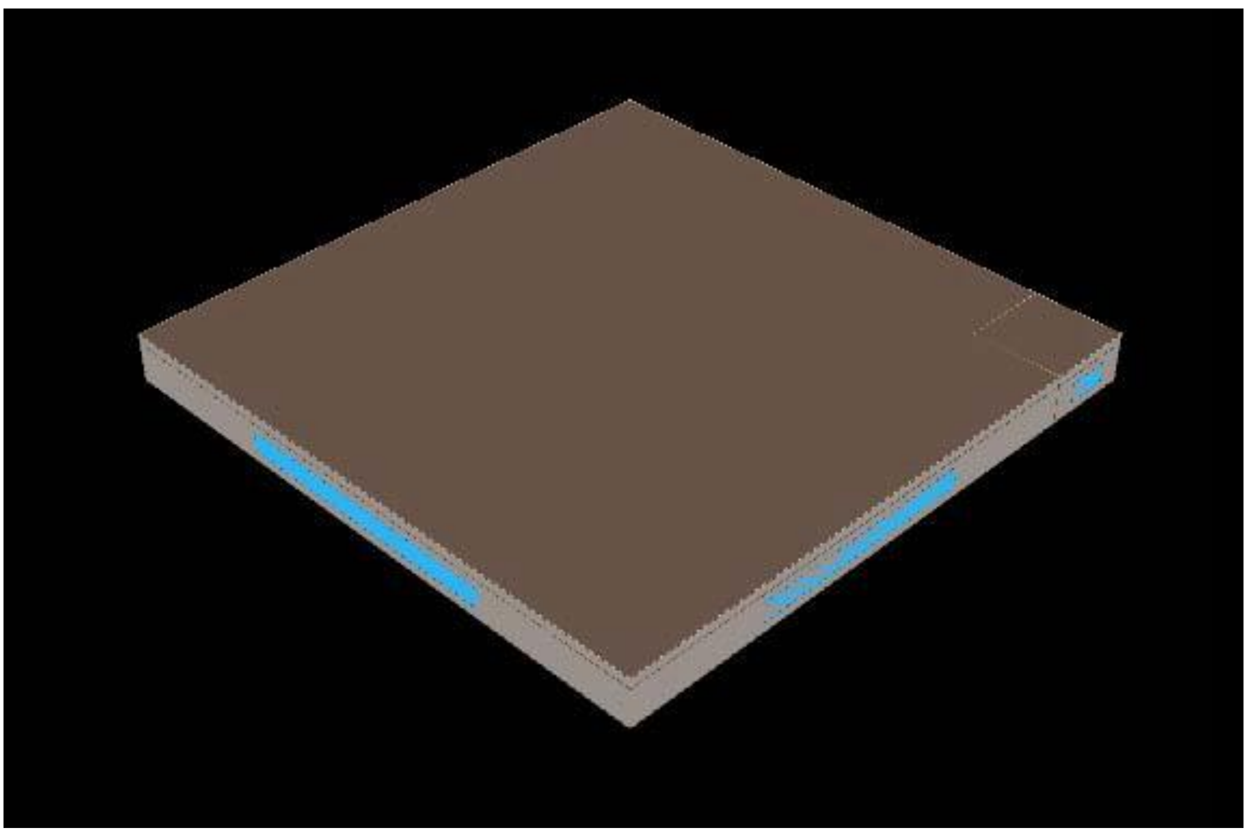


Figure 2. Assembly Building Rendering

Big Box Retail

A prototypical building energy simulation model for a big box retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 20.

Table 20. Big Box Retail Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	130,500 square feet Sales: 107,339 SF Storage: 11,870 SF Office: 4,683 SF Auto repair: 5,151 SF Kitchen: 1,459 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-7.5
Roof construction and R-value	Metal frame with built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Sales: 2.15 W/SF Storage: 0.85 W/SF (Active) 0.45 W/SF (Inactive) Office: 1.55 W/SF Auto repair: 1.7 W/SF Kitchen: 2.2 W/SF
Plug load density	Sales: 1.15 W/SF Storage: 0.23 W/SF Office: 1.73 W/SF Auto repair: 1.15 W/SF Kitchen: 3.23 W/SF
Operating hours	Mon-Sun: 10am – 9pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the prototype is shown in Figure 3.

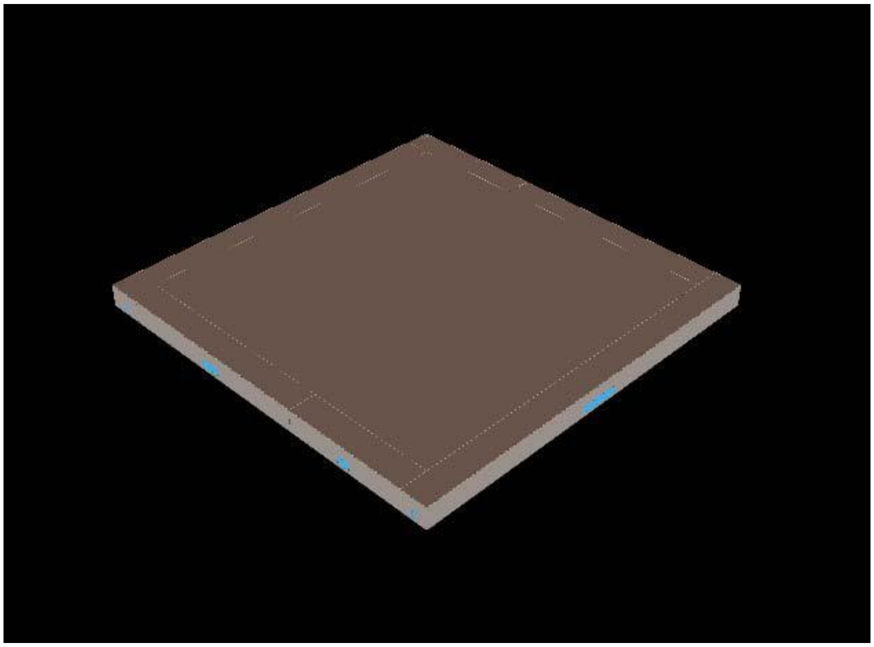


Figure 3. Big Box Retail Building Rendering

Fast Food Restaurant

A prototypical building energy simulation model for a fast food restaurant was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 21.

Table 21. Fast Food Restaurant Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square feet 1000 SF dining 600 SF entry/lobby 300 SF kitchen 100 SF restroom
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-7.5
Roof construction and R-value	Concrete deck with built-up roof, R-13.5
Glazing type	Multipane Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Dining: 1.7 W/SF Entry area: 1.7 W/SF Kitchen: 2.2 W/SF Restroom: 0.9 W/SF
Plug load density	0.6 W/SF dining 0.6 W/SF entry/lobby 4.3 W/SF kitchen 0.2 W/SF restroom
Operating hours	Mon-Sun: 6am – 11pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the prototype is shown in Figure 4.

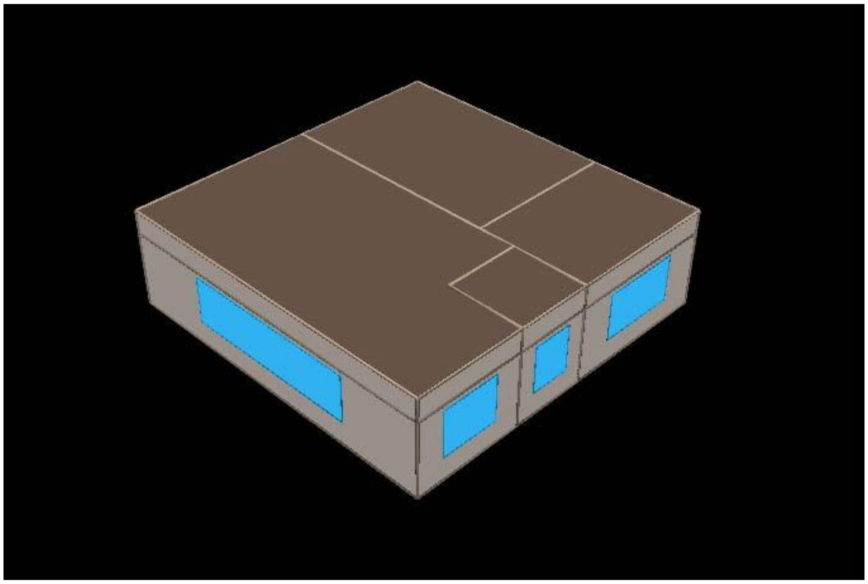


Figure 4. Fast Food Restaurant Building Rendering

Full-Service Restaurant

A prototypical building energy simulation model for a full-service restaurant was developed using the DOE-2.2 building energy simulation program. The characteristics of the full service restaurant prototype are summarized in Table 22.

Table 22. Full Service Restaurant Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2000 square foot dining area 600 square foot entry/reception area 1200 square foot kitchen 200 square foot restrooms
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Dining area: 1.7 W/SF Entry area: 1.7 W/SF Kitchen: 2.2 W/SF Restrooms: 1.5 W/SF
Plug load density	Dining area: 0.6 W/SF Entry area: 0.6 W/SF Kitchen: 3.1 W/SF Restrooms: 0.2 W/SF
Operating hours	9am – 12am
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the full-service restaurant prototype is shown in Figure 5.

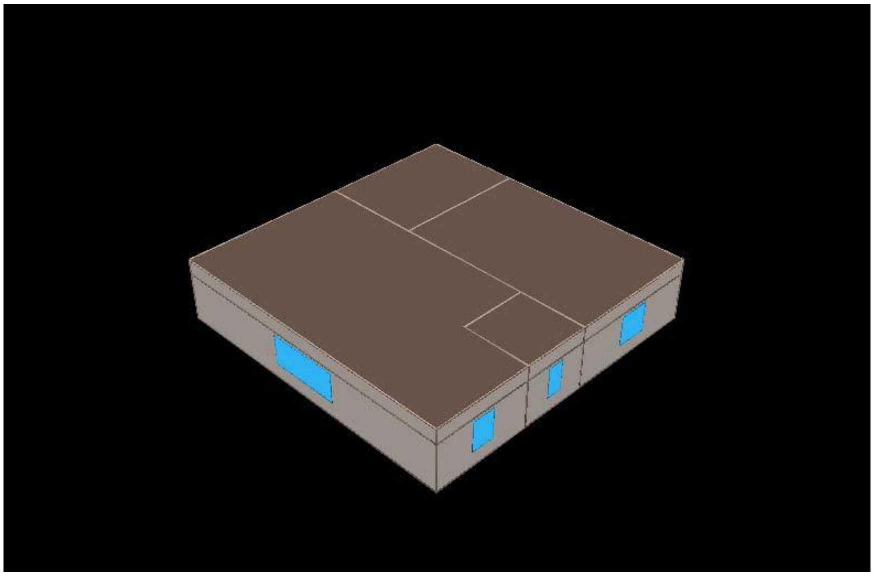


Figure 5. Full Service Restaurant Prototype Rendering

Grocery

A prototypical building energy simulation model for a grocery building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 23.

Table 23. Grocery Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	50,000 square feet Sales: 40,000 SF Office and employee lounge: 3,500 SF Dry storage: 2,860 SF 50 °F prep area: 1,268 SF 35 °F walk-in cooler: 1,560 SF
	- 5 °F walk-in freezer: 812 SF
Number of floors	1
Wall construction and R-value	Concrete block with insulation, R-5
Roof construction and R-value	Metal frame with built-up roof, R-12
Glazing type	Single pane clear
Lighting power density	Sales: 3.36 W/SF Office: 2.2 W/SF Storage: 1.82 W/SF 50°F prep area: 4.3 W/SF 35°F walk-in cooler: 0.9 W/SF - 5°F walk-in freezer: 0.9 W/SF
Equipment power density	Sales: 1.15 W/SF Office: 1.73 W/SF Storage: 0.23 W/SF 50°F prep area: 0.23 W/SF + 36 kBtu/hr process load 35°F walk-in cooler: 0.23 W/SF + 17 kBtu/hr process load - 5°F walk-in freezer: 0.23 W/SF+ 29 kBtu/hr process load
Operating hours	Mon-Sun: 6am – 10pm
HVAC system type	Packaged single zone, no economizer
Refrigeration system type	Air cooled multiplex
Refrigeration system size	Low temperature (-20°F suction temp): 23 compressor ton Medium temperature (18°F suction temp): 45 compressor ton
Refrigeration condenser size	Low temperature: 535 kBtu/hr THR Medium temperature: 756 kBtu/hr THR
Thermostat setpoints	Occupied hours: 74°F cooling, 70°F heating Unoccupied hours: 79°F cooling, 65°F heating

A computer-generated sketch of the prototype is shown in Figure 6.

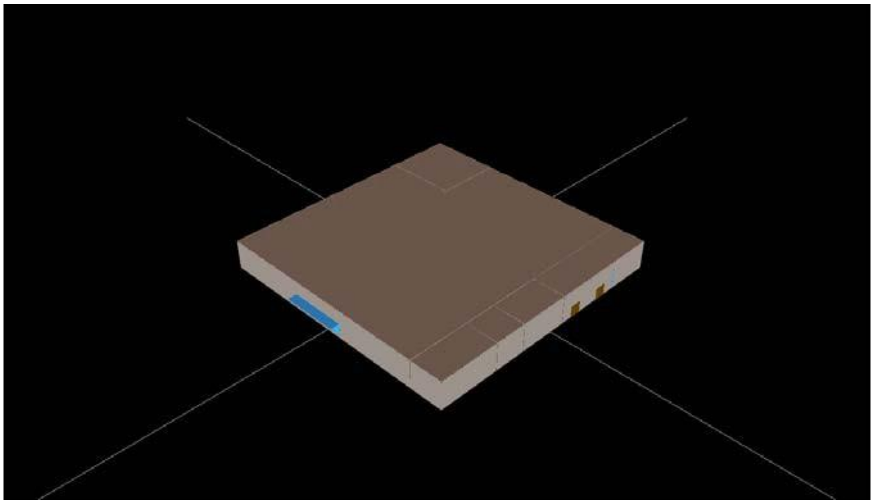


Figure 6. Grocery Building Rendering

Hospital

A prototypical building energy simulation model for a large hospital building was developed using the DOE-2.2 building energy simulation program. The simulations were driven using TMY3 long-term average weather data. The characteristics of the prototype are summarized below.

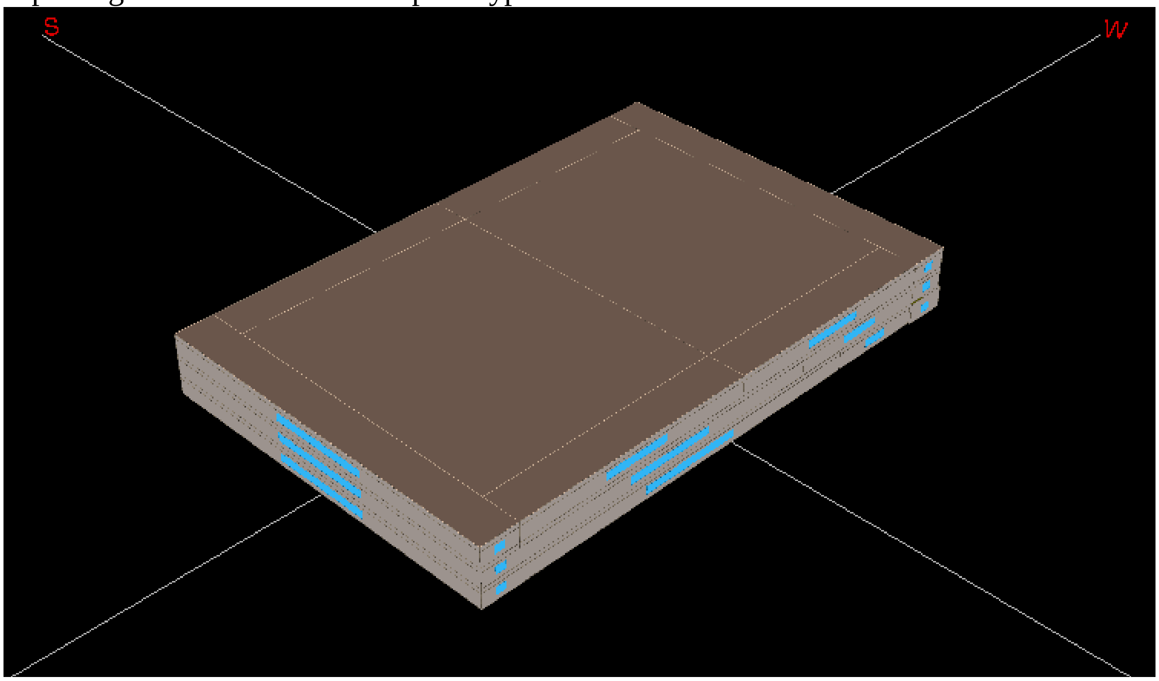
Large Hospital Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	250,000 square feet
Number of floors	3
Wall construction and R-value	Brick and CMU, R=7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Patient rooms: 2.3 W/SF Office: 2.2 W/SF Lab: 4.4 Dining: 1.7 Kitchen and food prep: 4.3
Plug load density	Patient rooms: 1.7 W/SF Office: 1.7 W/SF Lab: 1.7 Dining: 0.6 Kitchen and food prep: 4.6
Operating hours	24/7, 365
HVAC system types	Patient Rooms: 4 pipe fan coil Kitchen: Rooftop DX Remaining space; 1. Central constant volume system with hydronic reheat, without economizer; 2. Central constant volume system with hydronic reheat, with economizer; 3. Central VAV system with hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 deg F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 deg F setpoint
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 79 cooling, 69 heating

Each set of measures was run using each of three different HVAC system configurations: a constant volume reheat system without economizer, a constant volume reheat system with economizer, and a VAV system with economizer. The constant volume reheat system without economizer represents a system with the most heating and cooling operating hours, while the

VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the prototype is shown below.



Hospital Building Rendering

Hotel

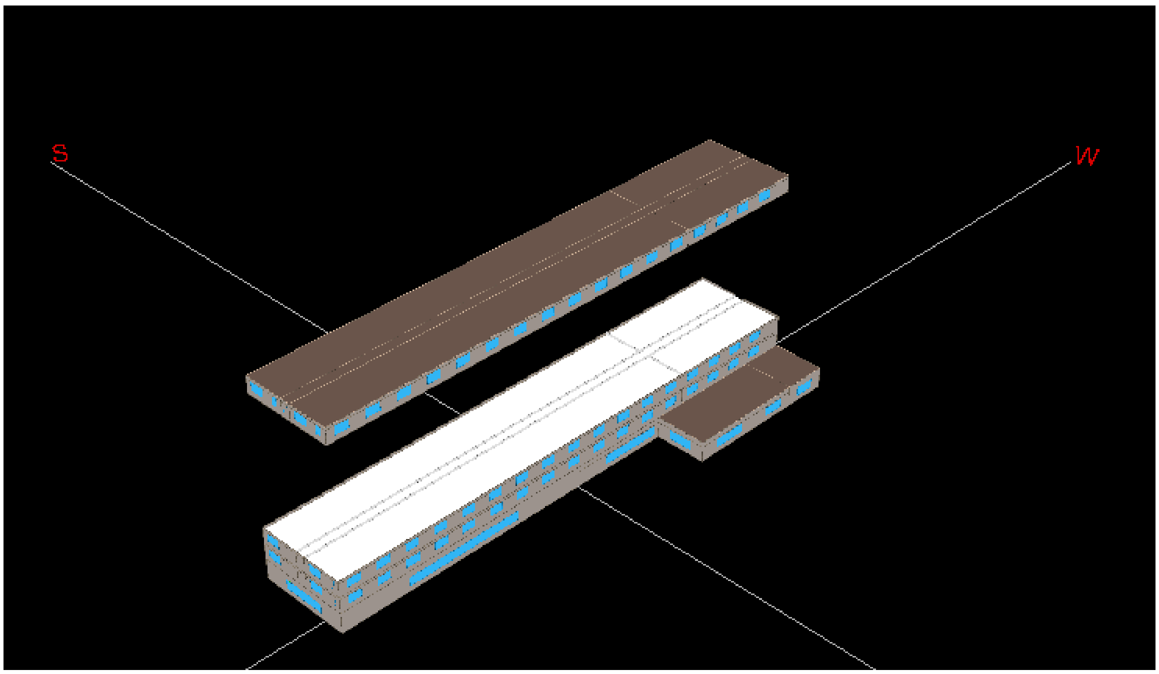
A prototypical building energy simulation model for a hotel building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized below.

Hotel Prototype Building Description

Characteristic	**Value**
Vintage	Existing (1970s) vintage
Size	200,000 square feet total Bar, cocktail lounge – 800 SF Corridor – 20,100 SF Dining Area – 1,250 SF Guest rooms – 160,680 SF Kitchen – 750 SF Laundry – 4,100 SF Lobby – 8,220 Office – 4,100 SF
Number of floors	11
Wall construction and R-value	Block construction, R-7.5
Roof construction and R-value	Wood deck with built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Bar, cocktail lounge – 1.7 W/SF Corridor – 1.0 W/SF Dining Area – 1.7 W/SF Guest rooms – 0.6 W/SF Kitchen – 4.3 W/SF Laundry – 1.8 W/SF Lobby – 3.1 W/SF Office – 2.2 W/SF
Plug load density	Bar, cocktail lounge – 1.2 W/SF Corridor – 0.2 W/SF Dining Area – 0.6 W/SF Guest rooms – 0.6 W/SF Kitchen – 3.0 W/SF Laundry – 3.5 W/SF Lobby – 0.6 W/SF Office – 1.7 W/SF
Operating hours	Rooms: 60% occupied 40% unoccupied All others: 24 hr / day
HVAC system type	Central built-up system: All except corridors and rooms 1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer PTAC : Guest rooms PSZ: Corridors

Characteristic	Value
HVAC system size	Based on ASHRAE design day conditions, 10% over-sizing assumed.
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 deg F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 deg F setpoint
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the prototype is shown below.



Hotel Building Rendering

Large Office

A prototypical building energy simulation model for a large office building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 24.

Table 24. Large Office Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	350,000 square feet
Number of floors	10
Wall construction and R-value	Glass curtain wall, R-7.5
Roof construction and R-value	Built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 W/SF Core offices: 1.45 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system types	1. Central constant volume system with perimeter hydronic reheat, without economizer; 2. Central constant volume system with perimeter hydronic reheat, with economizer; 3. Central VAV system with perimeter hydronic reheat, with economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing
Chiller type	Water cooled and air cooled
Chilled water system type	Constant volume with 3 way control valves,
Chilled water system control	Constant CHW Temp, 45 deg F setpoint
Boiler type	Hot water, 80% efficiency
Hot water system type	Constant volume with 3 way control valves,
Hot water system control	Constant HW Temp, 180 deg F setpoint
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

Each set of measures was run using each of three different HVAC system configurations – a constant volume reheat system without economizer, a constant volume reheat system with economizer and a VAV system with economizer. The constant volume reheat system without economizer represents system with the most heating and cooling operating hours, while the VAV system with economizer represents a system with the least heating and cooling hours. This presents a range of system loads and energy savings for each measure analyzed.

A computer-generated sketch of the prototype is shown in Figure 7. Note, the middle floors, since they are thermally equivalent, are simulated as a single floor, and the results are multiplied by 8 to represent the energy consumption of the 8 middle floors.

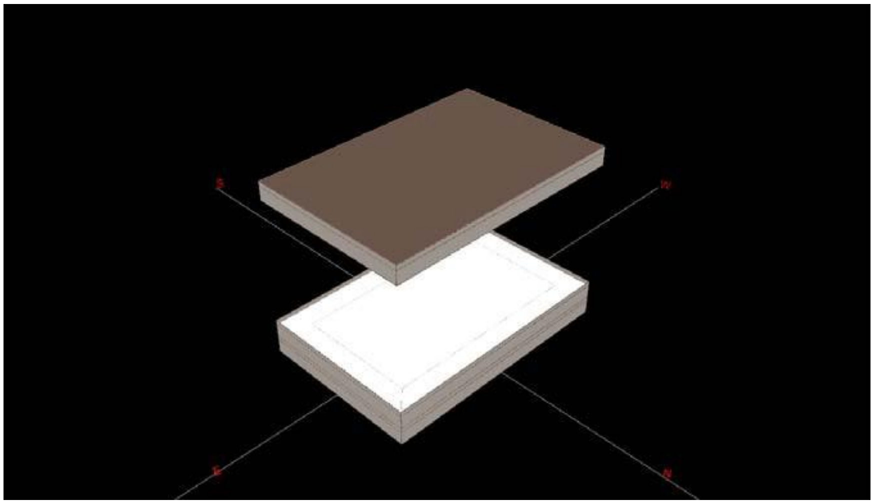


Figure 7. Large Office Building Rendering

Light Industrial

A prototypical building energy simulation model for a light industrial building was developed using the DOE-2.2 building energy simulation program. The characteristics of the prototype are summarized in Table 25.

Table 25. Light Industrial Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	100,000 square feet total 80,000 SF factory 20,000 SF warehouse
Number of floors	1
Wall construction and R-value	Concrete block with Brick, no insulation, R-5
Roof construction and R-value	Concrete deck with built-up roof, R-12
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Factory – 2.25 W/SF Warehouse – 0.7 W/SF
Plug load density	Factory – 1.2 W/SF Warehouse – 0.2 W/SF
Operating hours	Mon-Fri: 6am – 6pm Sat Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the prototype is shown in Figure 8.

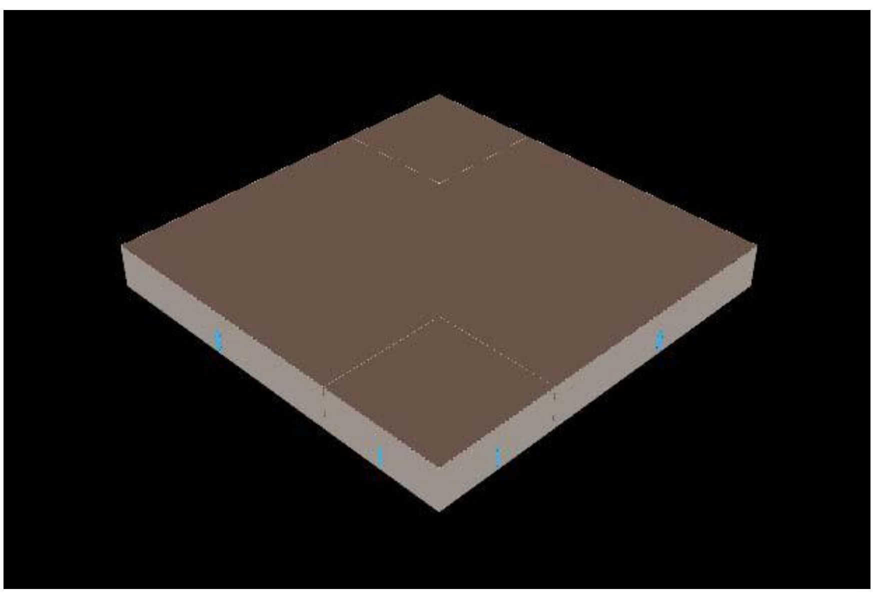


Figure 8. Light Industrial Building Rendering

Primary School

A prototypical building energy simulation model for an elementary school was developed using the DOE-2.2 building energy simulation program. The model is really of two identical buildings oriented in two different directions. The characteristics of the prototype are summarized in Table 26.

Table 26. Elementary School Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	2 buildings, 25,000 square feet each; oriented 90□ from each other Classroom: 15,750 SF Cafeteria: 3,750 SF Gymnasium: 3,750 SF Kitchen: 1,750 SF
Number of floors	1
Wall construction and R-value	Concrete with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Classroom: 1.8 W/SF Cafeteria: 1.3 W/SF Gymnasium: 1.7 W/SF Kitchen: 2.2 W/SF
Plug load density	Classroom: 1.2 W/SF Cafeteria: 0.6 W/SF Gymnasium: 0.6 W/SF Kitchen: 4.2 W/SF
Operating hours	Mon-Fri: 8am – 6pm Sun: 8am – 4pm
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the prototype is shown in Figure 9.

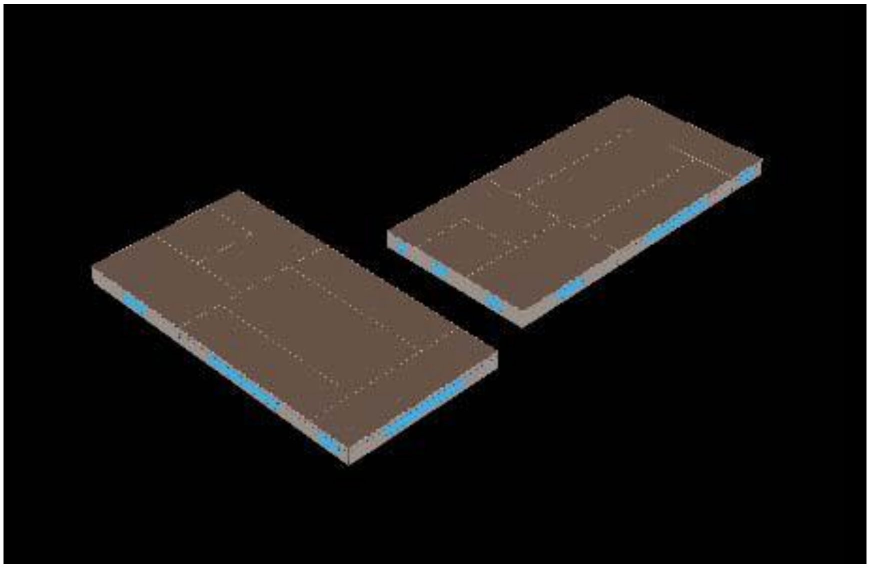


Figure 9. School Building Rendering

Small Office

A prototypical building energy simulation model for a small office was developed using the DOE-2.2 building energy simulation program. The characteristics of the small office prototype are summarized in Table 27.

Table 27. Small Office Prototype Building Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	10,000 square feet
Number of floors	2
Wall construction and R-value	Wood frame with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Perimeter offices: 1.55 W/SF Core offices: 1.45 W/SF
Plug load density	Perimeter offices: 1.6 W/SF Core offices: 0.7 W/SF
Operating hours	Mon-Sat: 9am – 6pm Sun: Unoccupied
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the small office prototype is shown in Figure 10.

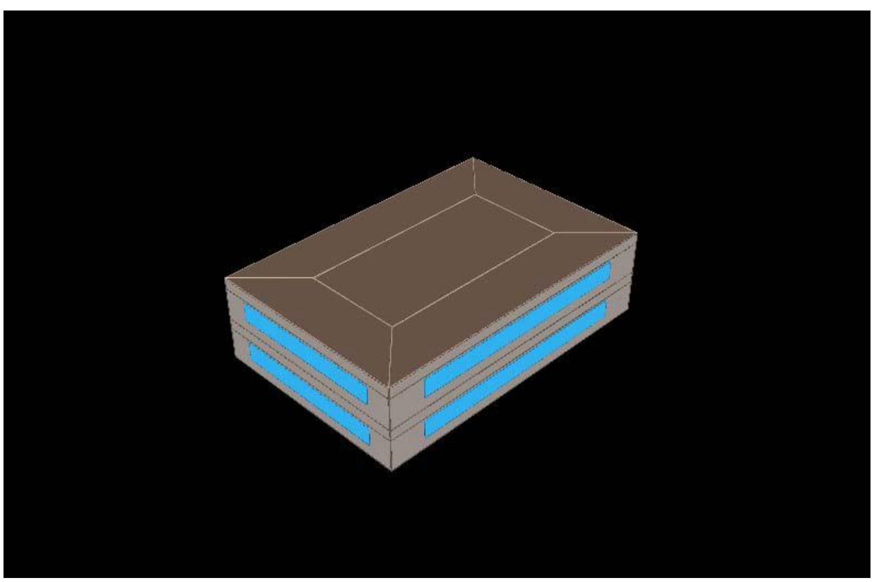


Figure 10. Small Office Prototype Building Rendering

Small Retail

A prototypical building energy simulation model for a small retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the small retail building prototype are summarized in Table 28.

Table 28. Small Retail Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	6400 square foot sales area 1600 square foot storage area 8000 square feet total
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-7.5
Roof construction and R-value	Wood frame with built-up roof, R-13.5
Glazing type	Multipane; Shading-coefficient = 0.84 U-value = 0.72
Lighting power density	Sales area: 2.15 W/SF Storage area: 0.85 W/SF (Active) 0.45 W/SF (Inactive)
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	10 – 10 Monday-Saturday 10 – 8 Sunday
HVAC system type	Packaged single zone, no economizer
HVAC system size	Based on ASHRAE design day conditions, 10% over sizing assumed.
Thermostat setpoints	Occupied hours: 75 cooling, 70 heating Unoccupied hours: 80 cooling, 65 heating

A computer-generated sketch of the small retail building prototype is shown in Figure 11.

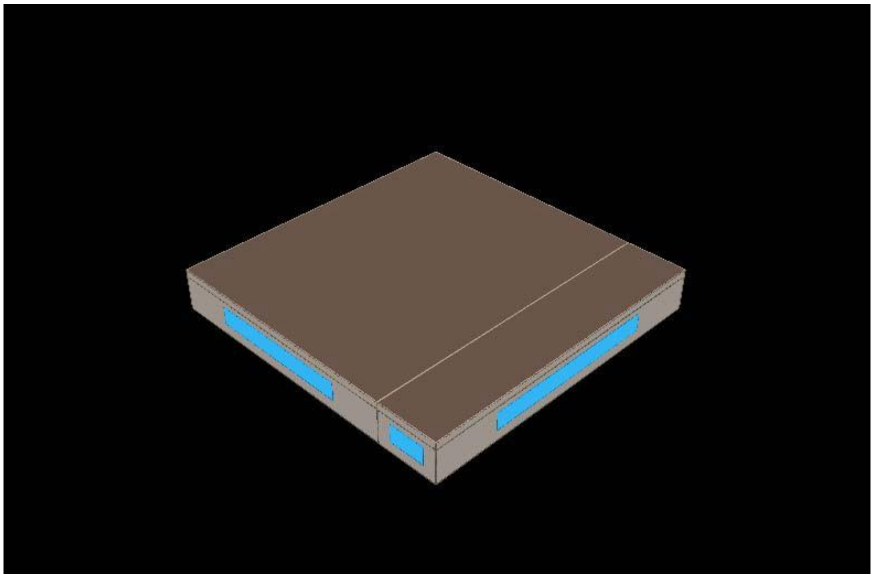


Figure 11. Small Retail Prototype Building Rendering

Appendix B – HVAC Interactive Effects Multipliers

Residential Buildings

City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg
Indianapolis	0.06	0.07	-0.0024	-0.17	0.03	0.00	-0.45	0.07	0.00	-0.52	0.00	0.00	0.00	0.00	-0.0024
South Bend	0.05	0.05	-0.0025	-0.18	0.00	0.00	-0.47	0.05	0.00	-0.54	0.00	0.00	0.00	0.00	-0.0025
Evansville	0.07	0.11	-0.0022	-0.11	0.10	0.00	-0.37	0.11	0.00	-0.45	0.00	0.00	0.00	0.00	-0.0022
Ft Wayne	0.05	0.05	-0.0026	-0.22	0.00	1.00	-0.50	0.05	1.00	-0.56	0.00	0.00	0.00	0.00	-0.0026
Terre Haute	0.07	0.08	-0.0024	-0.15	0.00	2.00	-0.42	0.08	2.00	-0.50	0.00	0.00	0.00	0.00	-0.0024

Data on HVAC system types in residential buildings were obtained from the Residential Energy Consumption Survey (RECS) for the East North Central census region (including IN and OH) to calculated weights for each HVAC system. These data are summarized below:

HVAC System Type	Million homes	Wt
AC Gas Heat	4.22	0.63
Heat pump	0.30	0.04
AC Electric Heat	1.18	0.18
Electric Heat Only	0.15	0.02
Gas Heat Only	0.85	0.13

Applying these weights to the WHF in the above table gives the following weighted averages by city, along with a statewide value assuming equal weights across cities:

City	Weighted		
	WHFe	WHFd	WHFg
Indianapolis	-0.061	0.055	-0.0018
South Bend	-0.070	0.038	-0.0019
Evansville	-0.034	0.092	-0.0017
Ft Wayne	-0.082	0.038	-0.0019
Terre Haute	-0.048	0.061	-0.0018
Statewide	**-0.059**	**0.057**	**-0.0018**

Commercial Buildings

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg
Assembly	Indianapolis	0.155	0.2	-0.0029	-0.174	0.2	0	-0.434	0.2	0	-0.591	0	0	0	0	-0.0029
	South Bend	0.133	0.2	-0.0023	-0.221	0.2	0	-0.349	0.2	0	-0.483	0	0	0	0	-0.0024
	Evansville	0.2	0.2	-0.0017	-0.042	0.2	0	-0.143	0.2	0	-0.318	0	0	0	0	-0.0017
	Ft Wayne	0.123	0.2	-0.003	-0.571	0.2	0	-0.485	0.2	0	-0.607	0	0	0	0	-0.0029
	Terre Haute	0.165	0.2	-0.0031	-0.184	0.2	0	-0.459	0.2	0	-0.604	0	0	0	0	-0.003
Big Box	Indianapolis	0.146	0.2	-0.0017	-0.086	0.2	0	-0.193	0.2	0	-0.318	0	0	0	0	-0.0017
	South Bend	0.133	0.2	-0.0019	-0.099	0.2	0	-0.242	0.2	0	-0.365	0	0	0	0	-0.0019
	Evansville	0.177	0.2	-0.0012	0.049	0.2	0	-0.043	0.2	0	-0.186	0	0	0	0	-0.0011
	Ft Wayne	0.126	0.2	-0.002	-0.16	0.2	0	-0.266	0.2	0	-0.371	0	0	0	0	-0.002
	Terre Haute	0.17	0.2	-0.0015	-0.028	0.2	0	-0.116	0.2	0	-0.28	0	0	0	0	-0.0015
Elemen-tary School	Indianapolis	0.096	0.2	-0.0033	-0.278	0.2	0	-0.605	0.2	0	-0.743	0	0	0	0	-0.0033
	South Bend	0.073	0.2	-0.0036	-0.318	0.2	0	-0.701	0.2	0	-0.839	0	0	0	0	-0.0036
	Evansville	0.126	0.2	-0.0029	-0.148	0.2	0	-0.465	0.2	0	-0.606	0	0	0	0	-0.0029
	Ft Wayne	0.069	0.2	-0.0037	-0.356	0.2	0	-0.736	0.2	0	-0.869	0	0	0	0	-0.0037
	Terre Haute	0.101	0.2	-0.0034	-0.274	0.2	0	-0.605	0.2	0	-0.784	0	0	0	0	-0.0034
Fast Food	Indianapolis	0.109	0.2	-0.0029	-0.023	0.2	0	-0.53	0.2	0	-0.661	0	0	0	0	-0.0032
	South Bend	0.09	0.2	-0.0032	-0.024	0.2	0	-0.586	0.2	0	-0.664	0	0	0	0	-0.0032
	Evansville	0.131	0.2	-0.0025	-0.016	0.2	0	-0.404	0.2	0	-0.677	0	0	0	0	-0.0033
	Ft Wayne	0.088	0.2	-0.0032	-0.026	0.2	0	-0.618	0.2	0	-0.66	0	0	0	0	-0.0032
	Terre Haute	0.112	0.2	-0.0029	-0.02	0.2	0	-0.505	0.2	0	-0.689	0	0	0	0	-0.0034
Full Service Rest-aurant	Indianapolis	0.108	0.2	-0.0033	-0.023	0.2	0	-0.556	0	0	-0.872	0	0	0	0	-0.0042
	South Bend	0.091	0.2	-0.0034	-0.024	0.2	0	-0.602	0	0	-0.746	0	0	0	0	-0.0036
	Evansville	0.135	0.2	-0.0026	-0.016	0.2	0	-0.372	0	0	-0.546	0	0	0	0	-0.0028
	Ft Wayne	0.088	0.2	-0.0036	-0.026	0.2	0	-0.638	0	0	-0.758	0	0	0	0	-0.0036
	Terre Haute	0.124	0.2	-0.0029	-0.02	0.2	0	-0.458	0	0	-0.628	0	0	0	0	-0.0031
Grocery	Indianapolis	0.146	0.2	-0.0017	-0.086	0.2	0	-0.193	0.2	0	-0.318	0	0	0	0	-0.0017

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg
	South Bend	0.133	0.2	-0.0019	-0.099	0.2	0	-0.242	0.2	0	-0.365	0	0	0	0	-0.0019
	Evansville	0.177	0.2	-0.0012	0.049	0.2	0	-0.043	0.2	0	-0.186	0	0	0	0	-0.0011
	Ft Wayne	0.126	0.2	-0.002	-0.16	0.2	0	-0.266	0.2	0	-0.371	0	0	0	0	-0.002
	Terre Haute	0.17	0.2	-0.0015	-0.028	0.2	0	-0.116	0.2	0	-0.28	0	0	0	0	-0.0015
Light Industrial	Indianapolis	0.096	0.2	-0.0022	-0.145	0.2	0	-0.332	0.2	0	-0.433	0	0	0	0	-0.0021
	South Bend	0.08	0.2	-0.0024	-0.173	0.2	0	-0.397	0.2	0	-0.496	0	0	0	0	-0.0024
	Evansville	0.123	0.2	-0.0018	-0.048	0.2	0	-0.217	0.2	0	-0.308	0	0	0	0	-0.0017
	Ft Wayne	0.074	0.2	-0.0025	-0.188	0.2	0	-0.407	0.2	0	-0.499	0	0	0	0	-0.0024
	Terre Haute	0.103	0.2	-0.0021	-0.099	0.2	0	-0.306	0.2	0	-0.394	0	0	0	0	-0.0021
Small Office	Indianapolis	0.119	0.2	-0.0016	-0.027	0.2	0	-0.182	0.2	0	-0.182	0	0	0	0	-0.0015
	South Bend	0.122	0.2	-0.0015	-0.015	0.2	0	-0.169	0.2	0	-0.169	0	0	0	0	-0.0014
	Evansville	0.144	0.2	-0.0012	0.051	0.2	0	-0.072	0.2	0	-0.072	0	0	0	0	-0.0009
	Ft Wayne	0.102	0.2	-0.0019	-0.112	0.2	0	-0.271	0.2	0	-0.271	0	0	0	0	-0.0018
	Terre Haute	0.124	0.2	-0.0016	-0.036	0.2	0	-0.184	0.2	0	-0.184	0	0	0	0	-0.0014
Small Retail	Indianapolis	0.124	0.2	-0.0023	-0.083	0.2	0	-0.315	0.2	0	-0.437	0	0	0	0	-0.0022
	South Bend	0.121	0.2	-0.0024	-0.088	0.2	0	-0.324	0.2	0	-0.445	0	0	0	0	-0.0022
	Evansville	0.157	0.2	-0.0016	0.023	0.2	0	-0.128	0.2	0	-0.264	0	0	0	0	-0.0015
	Ft Wayne	0.101	0.2	-0.0026	-0.168	0.2	0	-0.41	0.2	0	-0.51	0	0	0	0	-0.0025
	Terre Haute	0.145	0.2	-0.002	-0.076	0.2	0	-0.247	0.2	0	-0.381	0	0	0	0	-0.002
Ware-house	Indianapolis	0.096	0.2	-0.0022	-0.145	0.2	0	-0.332	0.2	0	-0.433	0	0	0	0	-0.0021
	South Bend	0.08	0.2	-0.0024	-0.173	0.2	0	-0.397	0.2	0	-0.496	0	0	0	0	-0.0024
	Evansville	0.123	0.2	-0.0018	-0.048	0.2	0	-0.217	0.2	0	-0.308	0	0	0	0	-0.0017
	Ft Wayne	0.074	0.2	-0.0025	-0.188	0.2	0	-0.407	0.2	0	-0.499	0	0	0	0	-0.0024
	Terre Haute	0.103	0.2	-0.0021	-0.099	0.2	0	-0.306	0.2	0	-0.394	0	0	0	0	-0.0021
Other	Indianapolis	0.115	0.2	-0.0023	-0.15	0.2	0	-0.357	0.185	0	-0.487	0	0	0	0	-0.0022
	South Bend	0.103	0.2	-0.0024	-0.159	0.2	0	-0.38	0.185	0	-0.488	0	0	0	0	-0.0021
	Evansville	0.142	0.2	-0.0019	-0.047	0.2	0	-0.24	0.185	0	-0.375	0	0	0	0	-0.0017
	Ft Wayne	0.095	0.2	-0.0026	-0.247	0.2	0	-0.448	0.185	0	-0.544	0	0	0	0	-0.0023

Building	City	AC with gas heat			Heat Pump			AC with electric heat			Electric heat only			Gas heat only		
		WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg	WHFe	WHFd	WHFg
	Terre Haute	0.126	0.2	-0.0023	-0.129	0.2	0	-0.345	0.185	0	-0.476	0	0	0	0	-0.0021

Appendix C Insulation Measures

Building: Single Family **City: Indianapolis** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	416.2	0.154	30.2												
19	467.6	0.205	33.8	51.4	0.051	3.7									
30	496.6	0.222	36.0	80.4	0.068	5.8	29.0	0.017	2.2						
38	505.3	0.239	36.8	89.1	0.085	6.6	37.7	0.034	3.0	8.7	0.017	0.8			
49	514.3	0.239	37.5	98.1	0.085	7.4	46.8	0.034	3.7	17.7	0.017	1.6	9.0	0.000	0.7
60	522.9	0.239	38.0	106.7	0.085	7.8	55.3	0.034	4.2	26.3	0.017	2.0	17.6	0.000	1.2

Building: Single Family **City: Indianapolis** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5043.2	0.410								
19	5588.4	0.495	545.2	0.085						
30	5902.4	0.546	859.2	0.137	314.0	0.051				
38	6022.0	0.563	978.8	0.154	433.6	0.068	119.6	0.017		
49	6128.3	0.580	1085.2	0.171	539.9	0.085	225.9	0.034	106.3	0.017
60	6194.0	0.580	1150.9	0.171	605.6	0.085	291.6	0.034	172.0	0.017

Building: Single Family			City: Indianapolis		HVAC: AC with Electric Heat				Measure: Roof Insulation	
Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7280.0	0.375								
19	8141.3	0.444	861.3	0.068						
30	8644.2	0.495	1364.2	0.119	502.9	0.051				
38	8837.4	0.512	1557.3	0.137	696.1	0.068	193.2	0.017		
49	9011.4	0.529	1731.4	0.154	870.1	0.085	367.2	0.034	174.1	0.017
60	9118.9	0.529	1838.9	0.154	977.6	0.085	474.7	0.034	281.6	0.017

Building: Single Family			City: Indianapolis		HVAC: Electric Heat, no AC				Measure: Roof Insulation	
Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	6942.2	0.000								
19	7766.6	0.000	824.4	0.000						
30	8247.6	0.000	1305.5	0.000	481.1	0.000				
38	8434.0	0.000	1491.8	0.000	667.4	0.000	186.3	0.000		
49	8596.1	0.000	1653.9	0.000	829.5	0.000	348.5	0.000	162.1	0.000
60	8701.9	0.000	1759.7	0.000	935.3	0.000	454.3	0.000	267.9	0.000

Building: Single Family **City: Indianapolis** **HVAC: Gas Heat with No AC** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	149.1	0.000	30.6												
19	166.7	0.000	34.4	17.6	0.000	3.7									
30	177.0	0.000	36.5	27.8	0.000	5.9	10.2	0.000	2.2						
38	180.9	0.000	37.4	31.7	0.000	6.7	14.2	0.000	3.0	3.9	0.000	0.9			
49	184.1	0.000	38.1	35.0	0.000	7.5	17.4	0.000	3.8	7.2	0.000	1.6	3.2	0.000	0.7
60	186.3	0.000	38.6	37.2	0.000	8.0	19.6	0.000	4.2	9.4	0.000	2.1	5.5	0.000	1.2

Building: Single Family **City: South Bend** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	351.2	0.137	30.4												
19	394.5	0.171	34.1	43.3	0.034	3.7									
30	417.2	0.188	36.2	66.0	0.051	5.9	22.7	0.017	2.2						
38	424.4	0.188	37.1	73.2	0.051	6.7	29.9	0.017	3.0	7.2	0.000	0.8			
49	433.1	0.188	37.8	81.9	0.051	7.4	38.6	0.017	3.7	15.9	0.000	1.6	8.7	0.000	0.8
60	437.9	0.188	38.3	86.7	0.051	7.9	43.3	0.017	4.2	20.6	0.000	2.1	13.5	0.000	1.2

Building: Single Family **City: South Bend** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5171.8	0.119								
19	5730.0	0.154	558.2	0.034						
30	6044.9	0.171	873.0	0.051	314.8	0.017				
38	6166.4	0.188	994.5	0.068	436.3	0.034	121.5	0.017		
49	6271.7	0.188	1099.8	0.068	541.6	0.034	226.8	0.017	105.3	0.000
60	6343.0	0.188	1171.2	0.068	613.0	0.034	298.1	0.017	176.6	0.000

Building: Single Family **City: South Bend** **HVAC: AC with Electric Heat** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7316.2	0.000								
19	8190.4	0.034	874.2	0.034						
30	8694.2	0.068	1378.0	0.068	503.8	0.034				
38	8892.2	0.068	1575.9	0.068	701.7	0.034	198.0	0.000		
49	9063.7	0.085	1747.4	0.085	873.2	0.051	369.5	0.017	171.5	0.017
60	9177.8	0.085	1861.6	0.085	987.4	0.051	483.6	0.017	285.7	0.017

Building: Single Family **City: South Bend** **HVAC: Electric Heat, no AC** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7061.6	0.000								
19	7905.5	0.000	843.9	0.000						
30	8393.2	0.000	1331.6	0.000	487.7	0.000				
38	8584.3	0.000	1522.7	0.000	678.8	0.000	191.1	0.000		
49	8750.3	0.000	1688.7	0.000	844.9	0.000	357.2	0.000	166.0	0.000
60	8859.0	0.000	1797.4	0.000	953.6	0.000	465.9	0.000	274.7	0.000

Building: Single Family **City: South Bend** **HVAC: Gas Heat with No AC** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	151.9	0.000	30.8												
19	170.0	0.000	34.6	18.1	0.000	3.8									
30	180.2	0.000	36.8	28.3	0.000	6.0	10.2	0.000	2.2						
38	184.1	0.000	37.6	32.3	0.000	6.8	14.2	0.000	3.1	3.9	0.000	0.9			
49	187.7	0.000	38.4	35.8	0.000	7.6	17.7	0.000	3.8	7.5	0.000	1.6	3.6	0.000	0.8
60	189.9	0.000	38.9	38.1	0.000	8.0	20.0	0.000	4.3	9.7	0.000	2.1	5.8	0.000	1.2

Building: Single Family **City: Evansville** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	475.3	0.392	24.2												
19	530.7	0.461	27.3	55.5	0.068	3.0									
30	562.1	0.512	29.0	86.9	0.119	4.8	31.4	0.051	1.8						
38	573.5	0.529	29.7	98.3	0.137	5.5	42.8	0.068	2.5	11.4	0.017	0.7			
49	582.4	0.546	30.3	107.2	0.154	6.1	51.7	0.085	3.1	20.3	0.034	1.3	8.9	0.017	0.6
60	588.6	0.563	30.7	113.3	0.171	6.5	57.8	0.102	3.5	26.5	0.051	1.7	15.0	0.034	1.0

Building: Single Family **City: Evansville** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	3299.0	0.631								
19	3673.2	0.717	374.2	0.085						
30	3886.9	0.751	587.9	0.119	213.7	0.034				
38	3968.4	0.768	669.5	0.137	295.2	0.051	81.6	0.017		
49	4042.0	0.785	743.0	0.154	368.8	0.068	155.1	0.034	73.5	0.017
60	4089.2	0.785	790.3	0.154	416.0	0.068	202.4	0.034	120.8	0.017

Building: Single Family **City: Evansville** **HVAC: AC with Electric Heat** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5831.6	0.580								
19	6547.1	0.648	715.5	0.068						
30	6959.0	0.683	1127.5	0.102	411.9	0.034				
38	7118.8	0.700	1287.2	0.119	571.7	0.051	159.7	0.017		
49	7260.1	0.700	1428.5	0.119	713.0	0.051	301.0	0.017	141.3	0.000
60	7351.2	0.717	1519.6	0.137	804.1	0.068	392.2	0.034	232.4	0.017

Building: Single Family **City: Evansville** **HVAC: Electric Heat, no AC** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5398.6	0.000								
19	6057.8	0.000	659.2	0.000						
30	6441.1	0.000	1042.5	0.000	383.3	0.000				
38	6591.1	0.000	1192.5	0.000	533.3	0.000	150.0	0.000		
49	6721.3	0.000	1322.7	0.000	663.5	0.000	280.2	0.000	130.2	0.000
60	6806.8	0.000	1408.2	0.000	749.0	0.000	365.7	0.000	215.7	0.000

Building: Single Family **City: Evansville** **HVAC: Gas Heat with No AC** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	115.5	0.000	24.6												
19	129.7	0.000	27.7	14.2	0.000	3.1									
30	137.7	0.000	29.5	22.2	0.000	4.9	8.0	0.000	1.8						
38	141.0	0.000	30.2	25.4	0.000	5.6	11.3	0.000	2.5	3.2	0.000	0.7			
49	143.7	0.000	30.8	28.2	0.000	6.2	14.0	0.000	3.1	6.0	0.000	1.3	2.7	0.000	0.6
60	145.4	0.000	31.2	29.9	0.000	6.6	15.7	0.000	3.5	7.7	0.000	1.7	4.4	0.000	1.0

Building: Single Family **City: Ft Wayne** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	339.2	0.171	32.0												
19	378.7	0.205	35.9	39.4	0.034	3.9									
30	399.7	0.239	38.1	60.4	0.068	6.1	21.0	0.034	2.3						
38	409.2	0.239	39.0	70.0	0.068	7.0	30.5	0.034	3.2	9.6	0.000	0.9			
49	417.4	0.256	39.8	78.2	0.085	7.8	38.7	0.051	3.9	17.7	0.017	1.7	8.2	0.017	0.8
60	421.7	0.256	40.3	82.4	0.085	8.3	43.0	0.051	4.4	22.0	0.017	2.2	12.5	0.017	1.3

Building: Single Family **City: Ft Wayne** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5507.3	0.051								
19	6091.0	0.085	583.6	0.034						
30	6427.1	0.102	919.8	0.051	336.2	0.017				
38	6555.6	0.102	1048.3	0.051	464.7	0.017	128.5	0.000		
49	6667.2	0.102	1159.9	0.051	576.3	0.017	240.1	0.000	111.6	0.000
60	6739.8	0.119	1232.4	0.068	648.8	0.034	312.6	0.017	184.1	0.017

Building: Single Family **City: Ft Wayne** **HVAC: AC with Electric Heat** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7528.7	0.171								
19	8421.0	0.205	892.3	0.034						
30	8941.0	0.239	1412.3	0.068	520.0	0.034				
38	9146.8	0.239	1618.1	0.068	725.8	0.034	205.8	0.000		
49	9326.1	0.256	1797.4	0.085	905.1	0.051	385.2	0.017	179.4	0.017
60	9441.8	0.256	1913.1	0.085	1020.8	0.051	500.9	0.017	295.1	0.017

Building: Single Family **City: Ft Wayne** **HVAC: Electric Heat, no AC** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7338.6	0.000								
19	8208.0	0.000	869.5	0.000						
30	8718.1	0.000	1379.5	0.000	510.1	0.000				
38	8917.9	0.000	1579.4	0.000	709.9	0.000	199.8	0.000		
49	9092.5	0.000	1753.9	0.000	884.5	0.000	374.4	0.000	174.6	0.000
60	9206.7	0.000	1868.1	0.000	998.6	0.000	488.6	0.000	288.7	0.000

Building: Single Family **City: Ft Wayne** **HVAC: Gas Heat with No AC** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	149.0	0.000	32.0												
19	166.4	0.000	35.8	17.4	0.000	3.9									
30	176.6	0.000	38.1	27.6	0.000	6.1	10.2	0.000	2.3						
38	180.5	0.000	39.0	31.6	0.000	7.0	14.2	0.000	3.2	3.9	0.000	0.9			
49	184.1	0.000	39.8	35.2	0.000	7.8	17.7	0.000	4.0	7.5	0.000	1.7	3.6	0.000	0.8
60	186.3	0.000	40.3	37.4	0.000	8.3	20.0	0.000	4.5	9.7	0.000	2.2	5.8	0.000	1.3

Building: Single Family **City: Terre Haute** **HVAC: AC with Gas Heat** **Measure: Roof Insulation**

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	344.0	0.188	31.9												
19	384.3	0.205	35.8	40.3	0.017	3.9									
30	406.0	0.222	38.1	61.9	0.034	6.2	21.7	0.017	2.3						
38	416.4	0.239	39.0	72.4	0.051	7.1	32.1	0.034	3.2	10.4	0.017	0.9			
49	420.6	0.239	39.8	76.6	0.051	7.9	36.3	0.034	4.0	14.7	0.017	1.7	4.3	0.000	0.8
60	426.3	0.239	40.3	82.3	0.051	8.4	42.0	0.034	4.5	20.3	0.017	2.2	9.9	0.000	1.3

Building: Single Family **City: Terre Haute** **HVAC: Heat Pump** **Measure: Roof Insulation**

Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	5539.8	0.188								
19	6144.0	0.205	604.3	0.017						
30	6488.6	0.222	948.8	0.034	344.5	0.017				
38	6621.2	0.239	1081.4	0.051	477.1	0.034	132.6	0.017		
49	6737.4	0.239	1197.6	0.051	593.3	0.034	248.8	0.017	116.2	0.000
60	6813.0	0.256	1273.2	0.068	668.9	0.051	324.4	0.034	191.8	0.017

Building:	Single Family		City: Terre Haute		HVAC: AC with Electric Heat				Measure: Roof Insulation	
Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7544.0	0.188								
19	8444.2	0.205	900.2	0.017						
30	8970.3	0.222	1426.3	0.034	526.1	0.017				
38	9178.5	0.239	1634.5	0.051	734.3	0.034	208.2	0.017		
49	9355.3	0.239	1811.3	0.051	911.1	0.034	385.0	0.017	176.8	0.000
60	9473.7	0.239	1929.7	0.051	1029.5	0.034	503.4	0.017	295.2	0.000

Building:	Single Family		City: Terre Haute		HVAC: Electric Heat, no AC				Measure: Roof Insulation	
Base	0		11		19		30		38	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	7354.6	0.000								
19	8232.6	0.000	878.0	0.000						
30	8747.6	0.000	1393.0	0.000	515.0	0.000				
38	8949.5	0.000	1594.9	0.000	716.9	0.000	201.9	0.000		
49	9125.8	0.000	1771.2	0.000	893.2	0.000	378.2	0.000	176.3	0.000
60	9241.0	0.000	1886.3	0.000	1008.4	0.000	493.3	0.000	291.5	0.000

Building: Single Family City: Terre Haute HVAC: Gas Heat with No AC Measure: Roof Insulation

Base	0			11			19			30			38		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	154.4	0.000	31.9												
19	172.7	0.000	35.8	18.3	0.000	3.9									
30	183.3	0.000	38.1	28.8	0.000	6.2	10.6	0.000	2.3						
38	187.4	0.000	39.0	32.9	0.000	7.1	14.7	0.000	3.2	4.1	0.000	0.9			
49	191.1	0.000	39.8	36.7	0.000	7.9	18.4	0.000	4.0	7.8	0.000	1.7	3.8	0.000	0.8
60	193.5	0.000	40.3	39.1	0.000	8.4	20.8	0.000	4.5	10.2	0.000	2.2	6.1	0.000	1.3

Building: Single Family City: Indianapolis HVAC: AC with Gas Heat Measure: Wall Insulation

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	96.0	0.073	8.1												
13	108.4	0.073	9.3	12.4	0.000	1.2									
17	128.2	0.091	11.1	32.2	0.018	3.0	19.8	0.018	1.8						
19	135.6	0.091	11.8	39.6	0.018	3.7	27.3	0.018	2.5	7.5	0.000	0.7			
21	140.5	0.109	12.4	44.5	0.036	4.3	32.2	0.036	3.1	12.4	0.018	1.2	4.9	0.018	0.6
25	152.2	0.109	13.2	56.2	0.036	5.1	43.8	0.036	3.9	24.0	0.018	2.1	16.5	0.018	1.4
27	156.0	0.109	13.6	60.0	0.036	5.5	47.6	0.036	4.3	27.8	0.018	2.5	20.4	0.018	1.8

Building: Single Family **City: Indianapolis** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1150.4	0.145								
13	1312.9	0.164	162.5	0.018						
17	1567.1	0.200	416.7	0.055	254.2	0.036				
19	1658.7	0.218	508.4	0.073	345.8	0.055	91.6	0.018		
21	1735.8	0.218	585.5	0.073	422.9	0.055	168.7	0.018	77.1	0.000
25	1855.1	0.236	704.7	0.091	542.2	0.073	288.0	0.036	196.4	0.018
27	1902.4	0.255	752.0	0.109	589.5	0.091	335.3	0.055	243.6	0.036

Building: Single Family **City: Indianapolis** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1866.2	0.127								
13	2135.5	0.145	269.3	0.018						
17	2556.2	0.182	690.0	0.055	420.7	0.036				
19	2709.3	0.182	843.1	0.055	573.8	0.036	153.1	0.000		
21	2837.8	0.200	971.6	0.073	702.4	0.055	281.6	0.018	128.5	0.018
25	3036.7	0.200	1170.5	0.073	901.3	0.055	480.5	0.018	327.5	0.018
27	3116.5	0.218	1250.4	0.091	981.1	0.073	560.4	0.036	407.3	0.036

Building: Single Family **City: Indianapolis** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1794.2	0.000								
13	2054.2	0.000	260.0	0.000						
17	2458.9	0.000	664.7	0.000	404.7	0.000				
19	2606.0	0.000	811.8	0.000	551.8	0.000	147.1	0.000		
21	2730.0	0.000	935.8	0.000	675.8	0.000	271.1	0.000	124.0	0.000
25	2920.2	0.000	1126.0	0.000	866.0	0.000	461.3	0.000	314.2	0.000
27	2998.4	0.000	1204.2	0.000	944.2	0.000	539.5	0.000	392.4	0.000

Building: Single Family **City: Indianapolis** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	39.3	0.000	8.1												
13	44.7	0.000	9.3	5.5	0.000	1.2									
17	53.6	0.000	11.2	14.4	0.000	3.0	8.9	0.000	1.8						
19	56.9	0.000	11.9	17.6	0.000	3.7	12.2	0.000	2.5	3.3	0.000	0.7			
21	59.6	0.000	12.4	20.4	0.000	4.3	14.9	0.000	3.1	6.0	0.000	1.2	2.7	0.000	0.6
25	63.8	0.000	13.3	24.5	0.000	5.2	19.1	0.000	4.0	10.2	0.000	2.1	6.9	0.000	1.5
27	65.5	0.000	13.7	26.2	0.000	5.5	20.7	0.000	4.3	11.8	0.000	2.5	8.5	0.000	1.8

Building: Single Family **City: South Bend** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	81.5	0.055	8.2												
13	91.6	0.055	9.5	10.2	0.000	1.3									
17	111.8	0.073	11.3	30.4	0.018	3.1	20.2	0.018	1.8						
19	117.6	0.073	12.0	36.2	0.018	3.8	26.0	0.018	2.5	5.8	0.000	0.7			
21	121.3	0.073	12.5	39.8	0.018	4.4	29.6	0.018	3.1	9.5	0.000	1.2	3.6	0.000	0.6
25	131.1	0.073	13.4	49.6	0.018	5.3	39.5	0.018	3.9	19.3	0.000	2.1	13.5	0.000	1.4
27	135.3	0.073	13.8	53.8	0.018	5.6	43.6	0.018	4.3	23.5	0.000	2.5	17.6	0.000	1.8

Building: Single Family **City: South Bend** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1160.0	0.055								
13	1338.5	0.073	178.5	0.018						
17	1591.3	0.091	431.3	0.036	252.7	0.018				
19	1682.0	0.091	522.0	0.036	343.5	0.018	90.7	0.000		
21	1756.2	0.091	596.2	0.036	417.6	0.018	164.9	0.000	74.2	0.000
25	1876.4	0.091	716.4	0.036	537.8	0.018	285.1	0.000	194.4	0.000
27	1924.5	0.109	764.5	0.055	586.0	0.036	333.3	0.018	242.5	0.018

Building: Single Family **City: South Bend** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1885.5	0.073								
13	2184.2	0.073	298.7	0.000						
17	2606.5	0.091	721.1	0.018	422.4	0.018				
19	2758.9	0.091	873.5	0.018	574.7	0.018	152.4	0.000		
21	2886.5	0.091	1001.1	0.018	702.4	0.018	280.0	0.000	127.6	0.000
25	3090.5	0.109	1205.1	0.036	906.4	0.036	484.0	0.018	331.6	0.018
27	3171.3	0.109	1285.8	0.036	987.1	0.036	564.7	0.018	412.4	0.018

Building: Single Family **City: South Bend** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1826.5	0.000								
13	2117.6	0.000	291.1	0.000						
17	2526.2	0.000	699.6	0.000	408.5	0.000				
19	2675.3	0.000	848.7	0.000	557.6	0.000	149.1	0.000		
21	2799.6	0.000	973.1	0.000	682.0	0.000	273.5	0.000	124.4	0.000
25	2995.8	0.000	1169.3	0.000	878.2	0.000	469.6	0.000	320.5	0.000
27	3074.2	0.000	1247.6	0.000	956.5	0.000	548.0	0.000	398.9	0.000

Building: Single Family **City: South Bend** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	40.0	0.000	8.2												
13	46.4	0.000	9.5	6.4	0.000	1.3									
17	55.5	0.000	11.4	15.5	0.000	3.2	9.1	0.000	1.9						
19	58.7	0.000	12.1	18.7	0.000	3.8	12.4	0.000	2.5	3.3	0.000	0.7			
21	61.5	0.000	12.6	21.5	0.000	4.4	15.1	0.000	3.1	6.0	0.000	1.2	2.7	0.000	0.6
25	65.6	0.000	13.5	25.6	0.000	5.3	19.3	0.000	4.0	10.2	0.000	2.1	6.9	0.000	1.5
27	67.5	0.000	13.9	27.5	0.000	5.7	21.1	0.000	4.3	12.0	0.000	2.5	8.7	0.000	1.8

Building: Single Family **City: Evansville** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	100.5	0.109	6.6												
13	118.4	0.127	7.6	17.8	0.018	1.1									
17	144.2	0.164	9.1	43.6	0.055	2.6	25.8	0.036	1.5						
19	151.8	0.164	9.7	51.3	0.055	3.1	33.5	0.036	2.1	7.6	0.000	0.5			
21	158.7	0.182	10.1	58.2	0.073	3.6	40.4	0.055	2.5	14.5	0.018	1.0	6.9	0.018	0.5
25	169.6	0.182	10.9	69.1	0.073	4.3	51.3	0.055	3.2	25.5	0.018	1.7	17.8	0.018	1.2
27	175.1	0.200	11.1	74.5	0.091	4.6	56.7	0.073	3.5	30.9	0.036	2.0	23.3	0.036	1.5

Building: Single Family **City: Evansville** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	760.9	0.127								
13	882.2	0.145	121.3	0.018						
17	1062.9	0.182	302.0	0.055	180.7	0.036				
19	1124.2	0.200	363.3	0.073	242.0	0.055	61.3	0.018		
21	1174.4	0.200	413.5	0.073	292.2	0.055	111.5	0.018	50.2	0.000
25	1255.3	0.218	494.4	0.091	373.1	0.073	192.4	0.036	131.1	0.018
27	1287.6	0.218	526.7	0.091	405.5	0.073	224.7	0.036	163.5	0.018

Building: Single Family **City: Evansville** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1479.6	0.109								
13	1716.7	0.127	237.1	0.018						
17	2062.5	0.145	582.9	0.036	345.8	0.018				
19	2184.0	0.164	704.4	0.055	467.3	0.036	121.5	0.018		
21	2286.4	0.164	806.7	0.055	569.6	0.036	223.8	0.018	102.4	0.000
25	2444.4	0.182	964.7	0.073	727.6	0.055	381.8	0.036	260.4	0.018
27	2507.8	0.182	1028.2	0.073	791.1	0.055	445.3	0.036	323.8	0.018

Building: Single Family **City: Evansville** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1381.1	0.000								
13	1602.4	0.000	221.3	0.000						
17	1925.3	0.000	544.2	0.000	322.9	0.000				
19	2038.9	0.000	657.8	0.000	436.5	0.000	113.6	0.000		
21	2133.8	0.000	752.7	0.000	531.5	0.000	208.5	0.000	94.9	0.000
25	2282.5	0.000	901.5	0.000	680.2	0.000	357.3	0.000	243.6	0.000
27	2342.4	0.000	961.3	0.000	740.0	0.000	417.1	0.000	303.5	0.000

Building: Single Family **City: Evansville** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	30.0	0.000	6.5												
13	34.9	0.000	7.6	4.9	0.000	1.1									
17	42.0	0.000	9.1	12.0	0.000	2.6	7.1	0.000	1.5						
19	44.4	0.000	9.7	14.4	0.000	3.1	9.5	0.000	2.1	2.4	0.000	0.5			
21	46.5	0.000	10.1	16.5	0.000	3.6	11.6	0.000	2.5	4.5	0.000	1.0	2.2	0.000	0.5
25	49.6	0.000	10.8	19.6	0.000	4.3	14.7	0.000	3.2	7.6	0.000	1.7	5.3	0.000	1.2
27	51.1	0.000	11.1	21.1	0.000	4.6	16.2	0.000	3.5	9.1	0.000	2.0	6.7	0.000	1.5

Building: Single Family **City: Ft Wayne** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	50.8	0.033	5.3												
13	58.5	0.043	6.1	7.7	0.011	0.8									
17	69.4	0.054	7.3	18.5	0.022	2.0	10.8	0.011	1.2						
19	73.4	0.054	7.8	22.5	0.022	2.4	14.8	0.011	1.6	4.0	0.000	0.4			
21	76.5	0.054	8.1	25.7	0.022	2.8	18.0	0.011	2.0	7.2	0.000	0.8	3.1	0.000	0.4
25	82.9	0.054	8.7	32.1	0.022	3.4	24.4	0.011	2.5	13.5	0.000	1.4	9.5	0.000	0.9
27	84.5	0.054	8.9	33.7	0.022	3.6	26.0	0.011	2.8	15.2	0.000	1.6	11.2	0.000	1.1

Building: Single Family **City: Ft Wayne** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	778.7	0.022								
13	897.9	0.022	119.2	0.000						
17	1062.4	0.033	283.8	0.011	164.5	0.011				
19	1122.6	0.033	343.9	0.011	224.7	0.011	60.2	0.000		
21	1172.0	0.033	393.3	0.011	274.1	0.011	109.6	0.000	49.4	0.000
25	1251.8	0.033	473.1	0.011	353.9	0.011	189.4	0.000	129.2	0.000
27	1282.0	0.043	503.4	0.022	384.1	0.022	219.6	0.011	159.4	0.011

Building: Single Family **City: Ft Wayne** **HVAC: AC with Electric Heat** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1218.4	0.033								
13	1409.0	0.043	190.5	0.011						
17	1677.1	0.054	458.7	0.022	268.2	0.011				
19	1775.1	0.054	556.7	0.022	366.1	0.011	98.0	0.000		
21	1856.7	0.054	638.3	0.022	447.8	0.011	179.6	0.000	81.6	0.000
25	1986.3	0.054	767.9	0.022	577.4	0.011	309.2	0.000	211.3	0.000
27	2037.4	0.054	819.0	0.022	628.4	0.011	360.3	0.000	262.3	0.000

Building: Single Family **City: Ft Wayne** **HVAC: Electric Heat, no AC** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1193.0	0.000								
13	1380.2	0.000	187.2	0.000						
17	1643.4	0.000	450.4	0.000	263.2	0.000				
19	1739.4	0.000	546.4	0.000	359.2	0.000	96.0	0.000		
21	1819.4	0.000	626.4	0.000	439.2	0.000	176.0	0.000	80.0	0.000
25	1945.5	0.000	752.4	0.000	565.3	0.000	302.1	0.000	206.0	0.000
27	1996.0	0.000	802.9	0.000	615.8	0.000	352.6	0.000	256.6	0.000

Building: Single Family **City: Ft Wayne** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	25.9	0.000	5.3												
13	29.9	0.000	6.1	4.0	0.000	0.8									
17	35.7	0.000	7.3	9.8	0.000	2.0	5.7	0.000	1.2						
19	37.7	0.000	7.8	11.8	0.000	2.4	7.8	0.000	1.6	2.1	0.000	0.4			
21	39.5	0.000	8.1	13.5	0.000	2.8	9.5	0.000	2.0	3.8	0.000	0.8	1.7	0.000	0.4
25	42.2	0.000	8.7	16.3	0.000	3.4	12.2	0.000	2.5	6.5	0.000	1.4	4.4	0.000	0.9
27	43.2	0.000	8.9	17.3	0.000	3.6	13.3	0.000	2.8	7.6	0.000	1.6	5.5	0.000	1.2

Building: Single Family **City: Terre Haute** **HVAC: AC with Gas Heat** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	49.2	0.033	5.1												
13	57.2	0.033	6.0	8.0	0.000	0.8									
17	72.6	0.043	7.1	23.4	0.011	2.0	15.4	0.011	1.2						
19	74.9	0.043	7.5	25.7	0.011	2.4	17.7	0.011	1.6	2.3	0.000	0.4			
21	79.4	0.043	7.9	30.2	0.011	2.8	22.2	0.011	1.9	6.8	0.000	0.8	4.6	0.000	0.4
25	84.5	0.054	8.5	35.3	0.022	3.3	27.3	0.022	2.5	11.9	0.011	1.3	9.6	0.011	0.9
27	88.0	0.054	8.7	38.8	0.022	3.5	30.8	0.022	2.7	15.4	0.011	1.6	13.1	0.011	1.1

Building: Single Family **City: Terre Haute** **HVAC: Heat Pump** **Measure: Wall Insulation**

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	760.8	0.033								
13	878.8	0.033	118.0	0.000						
17	1046.2	0.043	285.4	0.011	167.4	0.011				
19	1105.9	0.043	345.1	0.011	227.1	0.011	59.7	0.000		
21	1154.8	0.043	394.0	0.011	276.0	0.011	108.6	0.000	48.9	0.000
25	1233.0	0.054	472.3	0.022	354.2	0.022	186.9	0.011	127.1	0.011
27	1265.8	0.054	505.0	0.022	386.9	0.022	219.6	0.011	159.9	0.011

Building: Single Family City: Terre Haute HVAC: AC with Electric Heat Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1175.9	0.033								
13	1363.4	0.033	187.5	0.000						
17	1631.7	0.043	455.8	0.011	268.3	0.011				
19	1726.3	0.043	550.4	0.011	362.9	0.011	94.6	0.000		
21	1807.7	0.043	631.8	0.011	444.3	0.011	176.0	0.000	81.4	0.000
25	1933.8	0.054	757.9	0.022	570.3	0.022	302.1	0.011	207.5	0.011
27	1985.6	0.054	809.7	0.022	622.2	0.022	353.9	0.011	259.3	0.011

Building: Single Family City: Terre Haute HVAC: Electric Heat, no AC Measure: Wall Insulation

Base	0		11		13		17		19	
Measure	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF	kWh/ kSF	kW/ kSF
11	1151.6	0.000								
13	1335.1	0.000	183.5	0.000						
17	1593.5	0.000	441.9	0.000	258.4	0.000				
19	1688.1	0.000	536.4	0.000	352.9	0.000	94.5	0.000		
21	1766.6	0.000	615.0	0.000	431.5	0.000	173.1	0.000	78.6	0.000
25	1890.3	0.000	738.7	0.000	555.2	0.000	296.8	0.000	202.3	0.000
27	1939.7	0.000	788.1	0.000	604.6	0.000	346.2	0.000	251.7	0.000

Building: Single Family **City: Terre Haute** **HVAC: Gas Heat, no AC** **Measure: Wall Insulation**

Base	0			11			13			17			19		
Measure	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF	kWh/ kSF	kW/ kSF	MMBtu/ kSF
11	25.0	0.000	5.1												
13	29.0	0.000	6.0	4.0	0.000	0.8									
17	34.7	0.000	7.1	9.6	0.000	2.0	5.6	0.000	1.2						
19	36.7	0.000	7.6	11.7	0.000	2.4	7.7	0.000	1.6	2.1	0.000	0.4			
21	38.4	0.000	7.9	13.3	0.000	2.8	9.3	0.000	2.0	3.7	0.000	0.8	1.6	0.000	0.4
25	41.1	0.000	8.5	16.0	0.000	3.3	12.0	0.000	2.5	6.4	0.000	1.3	4.3	0.000	0.9
27	42.2	0.000	8.7	17.1	0.000	3.5	13.1	0.000	2.7	7.5	0.000	1.5	5.4	0.000	1.1