# State of Illinois

# Energy Efficiency

# Technical Reference Manual

# Effective:

# Friday, June 1st, 2012

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| SAG Stakeholders |
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| Ameren Illinois Company (Ameren) |
| Center for Neighborhood Technology (CNT) |
| Citizen's Utility Board (CUB) |
| City of Chicago |
| Commonwealth Edison Company (ComEd) |
| Energy Resources Center at the University of Illinois, Chicago (ERC) |
| Environment IL |
| Environmental Law and Policy Center (ELPC) |
| Future Energy Enterprises LLC |
| Illinois Attorney General's Office (AG) |
| Illinois Commerce Commission Staff (ICC Staff) |
| Illinois Department of Commerce and Economic Opportunity (DCEO) |
| Independent Evaluators (Navigant and Opinion Dynamics Corporation) |
| Integrys (Peoples Gas and North Shore Gas) |
| Metropolitan Mayor's Caucus (MMC) |
| Midwest Energy Efficiency Association (MEEA) |
| National Resources Defense Council (NRDC) |
| Nicor Gas |

**Table 1.1: Revision History**

| # | Document Title | Date | Reviewer | Status |
|---|---|---|---|---|
| 1 | Illinois_Statewide_TRM_HIM_1$^{st}$_Draft_012712.doc | 1/27/12 | VEIC | Original Draft |
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| 9 | GDS Comments on Draft_012712.doc | 2/23/12 | Travis Hink, GDS/Ameren | Reviewed |
| 10 | Illinois_Statewide_TRM_HIM_1$^{st}$_Draft_012712 Peoples Northshore comments.doc | 2/24/12 | George Roemer, Peoples Northshore | Reviewed |
| 11 | ELPC Comments on Draft High Impact TRM Illinois comments feb 26.doc | 2/26/12 | Geoff Crandall, ELPC | Reviewed |
| 12 | GDS Comments_Updated on Draft_012712.doc | 3/2/12 | Travis Hink, GDS/Ameren | Reviewed |
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| 15 | TRM_Draft_012712_KEMA comments_03 01 12.doc | 3/4/12 | KEMA | Reviewed |
| 16 | Addendum 0322 – Residential Gas Boiler and Furnace Measures Integrys comments.doc | 4/16/12 | Integrys | Reviewed |
| 17 | Addendum 0322 – Residential Gas Boiler and Furnace Measures_Navigant 2012 0412.doc | 4/12/12 | Navigant | Reviewed |
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| 19 | Addendum 0403 – Commercial Gas Boiler and Furnace Measures-Navigant 2012 0412.doc | 4/12/12 | Navigant | Reviewed |
| 20 | Addendum 0403 – Commercial Gas Boiler and Furnace Measures Nicor comments.doc | 4/13/12 | Nicor | Reviewed |
| 21 | Consolidated Commends from ComEd.doc | 4/13/12 | KEMA for ComEd | Reviewed |
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| 31 | Navigant Additional supporting docs for Residential Clothes washers.doc | 4/12/12 | Navigant | Reviewed |
| 32 | Navigant Analysis of ComEd Lighting EFLH from EMV 2012-04-04.doc | 4/4/12 | ComEd | Reviewed |
| 33 | KEMA TRM v2 Review 4/2/12.xls | 4/13/12 | ComEd | Reviewed |
| 34 | Navigant Supporting Calculations for Res Clothers Wathers 04-08-12.xls | 4/12/12 | Navigant | Reviewed |
| 35 | PY2 kWh by Facility TRM Comparison kb.xls | 4/13/12 | ComEd | Reviewed |
| 36 | TRM Application Issue Tracking Ameren ComEd MidAmerican_041212_Mtg.xls | 4/12/12 | Various | Reviewed |
| 37 | Illinois_Statewide_TRM_Comprehensive_Draft_ 031612_Stefano Galiasio on behalf of DCEO (2).doc | 5/1/12 | DCEO | Reviewed |
| 38 | Illinois_Statewide_TRM_Front_Matter_Draft_04 2712_ODC.docx | 4/30/12 | Opinion Dynamics | Reviewed |
| 39 | OAG Comments on Stipulation and TRM front chapters.docx | 5/8/12 | Attorney General | Reviewed |
| 40 | IL TRM front matter draft_CUB Comments_051112_excerpts.doc | 5/11/12 | CUB | Reviewed |
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| 45 | RE EE SAG Update IL TRM Policy and Process Issues; E-Mail list.txt | 5/11/12 | Annette Beitel | Reviewed |
| 46 | TRM Front Matter Comments 2012.05.11 kk.doc | 5/11/12 | Ameren | Reviewed |
| 47 | Nicor (Weaver) Front Matter Comments 5 11 12.docx | 5/11/12 | Nicor | Reviewed |
| 48 | Evaluator Team plus Weaver Comments on Front Matter.docx | 5/11/12 | Evaluator Team | Reviewed |
| 49 | VEIC May 18 Front Matter Draft kk.docx | 5/29/12 | Ameren | Reviewed |
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# 1 Purpose of the TRM

The purpose of this Technical Reference Manual (TRM) is to provide a transparent and consistent basis for calculating energy (kWh or therms) and capacity (kW) savings generated by the State of Illinois' energy efficiency programs[1]. To this end, the Vermont Energy Investment Corporation (VEIC) was retained by the Illinois Energy Association (IEA) on behalf of the Department of Commerce and Economic Opportunity (DCEO) and the state's electric and gas utilities[2] to prepare this TRM for statewide use.

The TRM is a policy document that is filed with the ICC for approval, and is intended to fulfill a series of objectives, including:

- "Serve as a common reference document for all stakeholders, Utilities / Program Administrators[3], and the Commission, so as to provide transparency to all parties regarding savings assumptions and calculations and the underlying sources of those assumptions and calculations.

- Support the calculation of the Illinois Total Resource Cost test (TRC), as well as other cost-benefit tests in support of program design, evaluation and regulatory compliance. Actual cost-benefit calculations and the calculation of avoided costs will not be part of this TRM.

- Identify gaps in robust, primary data for Illinois, that can be addressed via evaluation efforts and/or other targeted end-use studies. Contain a process for periodically updating and maintaining records, and preserve a clear record of what deemed parameters are/were in effect at what times to facilitate evaluation and data accuracy reviews.

- Provide standard protocols for determining energy savings for some common custom projects, as appropriate.[4]"

- "…support coincident peak capacity (for electric) savings estimates and calculations for electric Program Administrators in a manner consistent with the methodologies employed by the Program Administrator's Regional Transmission Organization ("RTO"), as well as those necessary for statewide Illinois tracking of coincident peak capacity impacts."[5]

- Provide a standardized, statewide methodology for calculating prescriptive energy and capacity savings, which gives independent evaluators a consistent framework from which to evaluate the savings achieved for the Illinois energy efficiency portfolios.

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1 Specifically, this TRM has been developed to help determine compliance with the energy efficiency requirements of the Illinois Public Utilities Act (220 ILCS 5), Sections 8-103 and 8-104
(http://www.ilga.gov/legislation/ilcs/ilcs5.asp?ActID=1277&ChapterID=23)
2 In addition to DCEO, the utilities include; Ameren Illinois, ComEd, Peoples Gas, Peoples North Shore and NICOR.
3 The Illinois Utilities subject to this TRM include: Ameren Illinois Company d/b/a Ameren Illinois (Ameren), Commonwealth Edison Company (ComEd), The Peoples Gas Light and Coke Company and North Shore Gas Company (Integrys), and Northern Illinois Gas Company d/b/a Nicor Gas (Nicor).
4 Illinois Statewide Technical Reference Manual Request for Proposals, August 22nd, 2011, pages 3-4,
"TRM_RFP_Final_part_1.230214520.pdf"
5 Ibid.

## 1.1   Enabling ICC Policy

This Illinois Statewide Technical Reference Manual (TRM) was developed to comply with the Illinois Commerce Commission (ICC or Commission) Final Orders from the electric and gas Utilities'[6] Energy Efficiency Plan dockets.  In the Final Orders, the ICC required the utilities to work with DCEO and the SAG to develop a statewide TRM.  *See, e.g.* ComEd Final Order *(Docket No. 10-0570, Final Order[7] at 59-60, December 21, 2010); Ameren's Final Order (Docket No. 10-0568, Order on Rehearing[8] at 19, May 24, 2011); Peoples Gas/North Shore Gas Final Order (Docket No. 10-0568, Order on Rehearing[9] at 19, May 24, 2011), and Nicor's Final Order (Docket No. 10-0562, Final Order[10] at 30, May 24, 2011).*

As directed in the Utilities' Efficiency Plan Orders, the SAG had the opportunity to, and also participated in, every aspect of the development of the TRM.  Interested members of the SAG participated in weekly teleconferences to review, comment, and participate in the development of the TRM.  The active participants in the TRM were designated as the "Technical Advisory Committee" (TAC).  The TAC participants were representatives from the following organizations:  the utilities (ComEd, Ameren IL, NICOR, Peoples Gas/North Shore Gas), DCEO, the Illinois Attorney General's Office, Natural Resources Defense Council (NRDC), the Environmental Law and Policy Center (ELPC), the Citizen's Utility Board, CNT Energy, the independent evaluators (Navigant and Opinion Dynamics Corporation), The University of Illinois at Chicago, and ICC Staff.

## 1.2   Development Process

The measure characterizations in this TRM are the result of a quantitative and qualitative analysis. The quantitative analysis took the form of a dynamic spreadsheet model of the engineering algorithms for measure level savings. These models were used to perform a sensitivity analysis on all of the algorithms' parameters, and have been reviewed weekly with the TAC during the December 2011 through May 2012 timeframe. VEIC has also presented status updates of the TRM at monthly large-group SAG meetings. The qualitative analysis includes the results of the quantitative analysis, and the result is the written measure characterizations in this document which are supported by referencing source documents for each of the parameters within the savings algorithm.

This document is a result of an ongoing review process involving the Illinois Commerce Commission (ICC) Staff (Staff or ICC Staff), the Utilities, DCEO, the Evaluators, the SAG TAC, and the SAG. VEIC met with the SAG and/or the TRM TAC weekly beginning in December 2011 through May 2012 to create a high level of transparency and vetting in the development of this TRM. The purpose of the weekly reviews was to maximize the level of collaboration and visibility into the measure characterization process. Where consensus did not emerge on specific measures or issues, this TRM contains VEIC's recommended approach along with source documentation and rationale. In keeping with the goal of transparency, a summary of the comments and their status to-date has been compiled under separate cover.

The VEIC analytical team noticed that many of the existing measures in Illinois represent discrete cases within a range of measure possibilities across Market Sectors, End Uses, Measures & Technologies, Programs and Fuels. This document has consolidated these measures in such a way that discrete measures can be captured within a more generalized format where only individual parameters in the savings algorithm need to be changed to arrive

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[6] The Illinois Utilities subject to this TRM include: Ameren Illinois Company d/b/a Ameren Illinois (Ameren), Commonwealth Edison Company (ComEd), The Peoples Gas Light and Coke Company and North Shore Gas Company (Integrys), and Northern Illinois Gas Company d/b/a Nicor Gas (Nicor).

[7] http://www.icc.illinois.gov/docket/files.aspx?no=10-0570&docId=159809

[8] http://www.icc.illinois.gov/docket/files.aspx?no=10-0568&docId=167031

[9] http://www.icc.illinois.gov/docket/files.aspx?no=10-0568&docId=167031

[10] http://www.icc.illinois.gov/docket/files.aspx?no=10-0562&docId=167027

at the savings claim for a discrete case. Finally, the measure titles used in this TRM may not match exactly the titles that the Utilities or DCEO efficiency programs use. However, in future filings at the ICC, the Program Administrators will use the Measure Codes described in Table 2.2  to allow for easy review and transparency across programs and portfolios.   An organizational structure, described in the next section, gives details about how measures are grouped, categorized, and described.

# 2   Using the TRM

For each measure characterization, this TRM includes engineering algorithm(s) and a value(s) for each parameter in the equation(s)[11]. These parameters have values that fall into one of three categories: a single deemed value, a lookup table of deemed values or an actual value such as the capacity of the equipment.   The TRM makes extensive use of lookup tables because they allow for an appropriate level of measure streamlining and customization within the context of an otherwise prescriptive measure.

Accuracy is the overarching principle that governs what value to use for each parameter.  When it is explicitly allowed within the text of the measure characterization, the preferred value is the actual or on-site value for the individual measure being implemented.  The *deemed values*[12] in the lookup tables are the next most accurate choice, and in the absence of either an actual value or an appropriate value in a lookup table, the single, *deemed value* should be used.  As a result, this single, *deemed value* can be thought of as a default value for that particular input to the algorithm.

A single *deemed savings estimate* is produced by any given combination of an algorithm and the allowable input values for each of its parameters.  In cases where lookup tables are provided, there is a range of deemed savings estimates that are possible, depending on site-specific factors such as equipment capacity, location and building type.

Algorithms and their parameter values are included for calculating estimated:

- Gross annual electric energy savings (kWh)

- Gross annual fossil fuel energy savings (therms)

- Gross electric summer coincident peak demand savings (kW)

To support cost-effectiveness calculations, parameter values are also included for:

- Incremental costs ($)

- Measure life (years)

- Operation and maintenance costs ($)

- Water (gal) and other resource savings where appropriate.

To facilitate the use of the TRM as measures are revised, updated, and removed, a unique code is provided for each measure that identifies the measure and the applicable installed program year.

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[11] As noted in the RFP, the net-to-gross ratios are provided by the evaluators and are listed in the appendices.
[12] Emphasis has been added to denote the difference between a "deemed value" and a "deemed savings estimate".  A deemed value refers to a single input value to an algorithm, while a deemed savings estimate is the result of calculating the end result of all of the values in the savings algorithm.

## 2.1 Organizational Structure

The organization of this document follows a three-level format, each of which is a major heading in the Table of Contents. These levels are designed to define and clarify what the measure is and where it is applied.

1. **Market Sectors[13]**
   o This level of organization specifies the type of customer the measure applies to, either Commercial and Industrial or Residential.
   o Answers the question, "What category best describes the customer?"

2. **End-use Category**
   o This level of organization represents most of the major end-use categories for which an efficient alternative exists. The following table lists all of the end-use categories in this version of the TRM.
   o Answers the question, "To what end-use category does the measure apply?"

**Table 2.1: End-Use Categories in the TRM[14]**

| Residential Market Sector | Commercial and Industrial Market Sector |
|---|---|
| Appliances | Agricultural Equipment |
| Consumer Electronics | Food Service Equipment |
| Hot Water | Hot Water |
| HVAC | HVAC |
| Lighting | Lighting |
| Shell | Miscellaneous |
| | Refrigeration |

3. **Measure & Technology**
   o This level of organization represents individual efficient measures such as CFL lighting and LED lighting, both of which are individual technologies within the Lighting end-use category.
   o Answers the question, "What technology defines the measure?"

This organizational structure is silent on which fuel the measure is designed to save; electricity or natural gas. By organizing the TRM this way, measures that save on both fuels do not need to be repeated. As a result, the TRM will be easier to use and to maintain.

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[13] Note that the Public Building and low income measures that DCEO administers are not listed as a separate Market Sector. This building type is one of a series of building types that are included in the appropriate measures in the Non-Residential Sector.

[14] Please note that this is not an exhaustive list of end-uses and that others may be included in future versions of the TRM.

## 2.2   Measure Code Specification

In order to uniquely identify each measure in the TRM, abbreviations for the major organizational elements of the TRM have been established.  When these abbreviations are combined and delimited by a dash ('-') a unique, 18-character alphanumeric code is formed that can be used for tracking the measures and their associated savings estimates.  Measure codes appear at the end of each measure and are structured using five parts.

**Code Structure = Market + End-use Category + Measure + Version # + Effective Date**

For example, the commercial boiler measure is coded: "CI-HVC-BLR_-V01-120601"

**Table 2.2: Measure Code Specification Key**

| Market (@@) | End-use (@@@) | Measure (@@@@) | Version (V##) | Effective Date |
|---|---|---|---|---|
| CU (Custom) | AGE (Agricultural Equipment) | BLR_ | V01 | YYMMDD |
| CI (C&I) | APL (Appliances) | T5F_ | V02 | YYMMDD |
| RS (Residential) | CEL (Consumer Electronics) | T8F_ | V03 | YYMMDD |
| | FSE (Food Service Equipment) | Etc | … | … |
| | HVC (HVAC) | | | |
| | HW_ (Hot Water) | | | |
| | LTG (Lighting) | | | |
| | MSC (Miscellaneous) | | | |
| | RFG (Refrigeration) | | | |
| | SHL (Shell) | | | |

## 2.3   Components of TRM Measure Characterizations

Each measure characterization uses a standardized format that includes at least the following components. Measures that have a higher level of complexity may have additional components, but also follow the same format, flow and function.

**DESCRIPTION**

**DEFINITION OF EFFICIENT EQUIPMENT**

**DEFINITION OF BASELINE EQUIPMENT**

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

**DEEMED MEASURE COST**

**DEEMED O&M COST ADJUSTMENTS**

**LOADSHAPE**

**COINCIDENCE FACTOR**

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**Algorithm**

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**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

**NATURAL GAS SAVINGS**

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

**DEEMED O&M COST ADJUSTMENT CALCULATION**

**MEASURE CODE**

## 2.4    Applying Deemed Incremental Costs to Measure Screening

Each measure includes at least one deemed incremental cost(s) for each measure as a default value(s).  However, Direct Install programs may have better information on the true incremental cost of their measures.  In instances like this, program administrators may use their own, custom incremental cost value for the purposes of measure screening subject to the requirement that it document the decision in its reporting, bring the results to the SAG for its review and submit the change to the TRM Update Procedure during the next update cycle.

## 2.5    Parameter Input Tables

Many of the measures in this TRM require the user to select the appropriate input value from a list of inputs for a given parameter in the savings algorithm.  Where the TRM asks the user to select the input, look up tables of allowable values are provided.  For example, a set of input parameters may depend on building type; while a range of values may be given for each parameter, only one value is appropriate for any specific building type. If no table of alternative inputs is provided for a particular parameter, then the single deemed value will be used, unless the entire measure is implemented on a custom basis.

## 2.6    Measure Expansion Protocol for Custom Application of TRM Measures

A TRM measure may be treated as a "Custom" rather than a "Prescriptive" measure as long as the measure is treated as a custom measure on a consistent basis within the program in question.  In such cases where otherwise prescriptive measures within the TRM are implemented on a custom basis, the Measure Expansion Protocol must be applied as described in detail in Section 8.

## 2.7    Program Delivery & Baseline Definitions

The measure characterizations in this TRM are not grouped by program delivery type, which is a common approach in other states.  As a result, the measure characterizations provided include information and assumptions to support savings calculations for the range of program delivery options commonly used for the measure.  The organizational significance of this approach is that multiple baselines, incremental costs, O&M costs, measure lives and in-service rates are included in the measure characterization(s) that are delivered under two or more different program designs. Values appropriate for each given program delivery type are clearly specified in the algorithms or in look up tables within the characterization.

Care has been taken to clearly define in the measure's description the types of program delivery that the measure characterization is designed to support.  However, there are no universally accepted definitions for a particular program type, and the description of the program type(s) may differ by measure.  Nevertheless, program delivery types can be generally defined according to the following table.  These are the definitions used in the measure descriptions, and, when necessary, individual measure descriptions may further refine and clarify these definitions of program delivery type.

**Table 2.3: Program Delivery Types**

| Program | Attributes |
|---|---|
| Time of Sale (TOS) | <u>Definition:</u> A program in which the customer is incented to purchase or install higher efficiency equipment than if the program had not existed. This may include retail rebate (coupon) programs, upstream buydown programs, online store programs, contractor based programs, or CFL giveaways as examples.<br><u>Baseline</u> = New equipment<br><u>Efficient Case</u> = New, premium efficiency equipment above federal and state codes and standard industry practice.<br><u>Example:</u> CFL rebate |
| New Construction (NC) | <u>Definition:</u> A program that intervenes during building design to support the use of more-efficient equipment and construction practices.<br><u>Baseline</u> = Building code or federal standards.<br><u>Efficient Case</u> = The program's level of building specification<br><u>Example:</u> Building shell and mechanical measures |
| Retrofit (RF) | <u>Definition:</u> A program that *upgrades* existing equipment before the end of its useful life.<br><u>Baseline</u> = Existing equipment or the existing condition of the building or equipment. A single baseline applies over the measure's life.<br><u>Efficient Case</u> = New, premium efficiency equipment above federal and state codes and standard industry practice.<br><u>Example:</u> Air sealing and insulation. |
| Early Replacement (EREP) | <u>Definition:</u> A program that *replaces* existing equipment before the end of its expected life.<br><u>Baseline</u> = Dual; it begins as the existing equipment and shifts to new baseline equipment after the expected life of the existing equipment is over.<br><u>Efficient Case</u> = New, premium efficiency equipment above federal and state codes and standard industry practice.<br><u>Example:</u> Refrigerators, Freezers |
| Early Retirement (ERET) | <u>Definition:</u> A program that *retires* duplicative equipment before its expected life is over.<br><u>Baseline</u> = The existing equipment, which is retired and not replaced.<br><u>Efficient Case</u> = Zero because the unit is retired.<br><u>Example:</u> Appliance recycling |
| Direct Install (DI) | <u>Definition:</u> A program where measures are installed during a site visit.<br><u>Baseline</u> = Existing equipment<br><u>Efficient Case</u> = New, premium efficiency equipment above federal and state codes and standard industry practice.<br><u>Example:</u> Lighting and low-flow hot water measures |

The concept and definition of the baseline is a key element of every measure characterization and is directly related to the program delivery type. Without a clear definition of the baseline, the savings algorithms cannot be adequately specified and subsequent evaluation efforts would be hampered. As a result, each measure has a detailed description (and in many cases, specification) of the specific baseline that should be used to calculate savings. Baselines in this TRM fall into one of the following five categories, and are organized within each measure characterization by the program delivery type to which it applies.

1. **Building Code:** As defined by the minimum specifications required under state energy code or applicable federal standards.

2. **Existing Equipment**: As determined by the most representative (or average) example of equipment that is in the existing stock. Existing equipment baselines apply over the equipment's remaining useful life.

3. **New Equipment**: As determined by the equipment that represents standard practice in the current market environment. New equipment baselines apply over the effective useful life of the measure.

4. **Dual Baseline**: A baseline that begins as the Existing Equipment and shifts to New Equipment after the expected life of the existing equipment is over.

5. **Zero Baseline**: A baseline that is applicable to early retirement measures where the existing equipment is no longer in service.

## 2.8   High Impact Measures

Measures that are expected to collectively account for at least 80% of statewide energy savings are considered high impact measures. The following tables list these measures and show the section in which they may be found.

**Table 2.4: Commercial and Industrial High Impact Measures**

| Section | End-use | Technology / Measure |
|---|---|---|
| 6.2.3 | Food Service | Commercial Steam Cooker |
| 6.2.11 | Food Service | High Efficiency Pre-Rinse Spray Valve |
| 6.4.3 | HVAC | Process Boiler Tune-up |
| 6.4.4 | HVAC | Boiler Lockout/Reset Controls |
| 6.4.10 | HVAC | High Efficiency Boilers |
| 6.4.11 | HVAC | High Efficiency Furnace |
| 6.4.15 | HVAC | Steam Trap Replacement or Repair |
| 6.4.16 | HVAC | Variable Speed Drives for HVAC |
| 6.5.1 | Lighting | CFL |
| 6.5.2 | Lighting | ILED |
| 6.5.3 | Lighting | High Performance T8 Fixtures and Lamps |
| 6.5.4 | Lighting | T5 |
| 6.5.5 | Lighting | Lighting Controls |
| 6.6.6 | Lighting | Lighting Power Density Reduction |
| 6.5.7 | Lighting | LED Traffic and Pedestrian Signals |
| 6.3.4 | Hot Water | Tankless Water Heater |

**Table 2.5: Residential High Impact Measures**

| Section | End-use | Technology / Measure |
|---------|---------|----------------------|
| 7.1.2 | Appliances | Clothes Washer |
| 7.1.8 | Appliances | Refrigerator & Freezer Recy. |
| 7.4.2 | Hot Water | Gas Water Heater |
| 7.4.3 | Hot Water | Heat Pump Water Heater |
| 7.4.4 | Hot Water | Low Flow Faucet Aerator |
| 7.4.5 | Hot Water | Low Flow Showerhead |
| 7.3.1 | HVAC | Air Source Heat Pump |
| 7.3.2 | HVAC | Central Air Conditioning |
| 7.3.4 | HVAC | Furnace Blower Motor |
| 7.3.5 | HVAC | Gas High Efficiency Boiler |
| 7.3.6 | HVAC | Gas High Efficiency Furnace |
| 7.3.10 | HVAC | Programmable Thermostats |
| 7.5.5 | Lighting | LED Downlights |
| 7.5.2 | Lighting | Specialty CFL |
| 7.5.1 | Lighting | Standard CFL |
| 7.6.1 | Shell | Air Sealing |
| 7.6.2 | Shell | Basement Sidewall Insulation |
| 7.6.4 | Shell | Wall and Ceiling Insulation |

# 3 Policies for Applying the TRM to Energy Efficiency Programs

This section defines the policies various stakeholders will follow to apply the TRM in the implementation, evaluation, and planning of Illinois Energy Efficiency programs.

## 3.1 Submitting the TRM to the ICC

The TRM will be submitted to the ICC annually and may take the form of a joint filing on the part of DCEO, the Utilities and participating members of the SAG.

## 3.2 SAG Consensus on TRM Development

Each Utility's Order enables it to implement energy efficiency programs and also provides guidance concerning the TRM. Generally speaking, these Orders describe the TRM's creation and maintenance as being a collaborative process between the Utilities (who in this context are also efficiency Program Administrators[15]), DCEO and the SAG.

As a result and as a document that applies statewide, the TRM has been and will continue to be developed through a collaborative consensus using the SAG process[16]. In practice, this means that the TAC will work toward consensus on the issue first, and then bring the result to the larger SAG for its review and comment. Once consensus develops at the SAG level, the TRM Administrator will include the changes in the next version of the TRM[17].

In cases where consensus does not emerge out of the SAG process, the TRM Administrator will include its recommended resolution to the issue in the next filed TRM, and until the ICC resolves the issue, the Program Administrators may proceed with their preferred program and measure implementation. In addition, the document filed with the ICC will include a "Comparison Exhibit" that clearly lays out the different positions on non-consensus issues, and, to the extent possible, identify the parties who support each position.

## 3.3 Applicability of the TRM

Consistent with Commission policy, the Program Administrators have the flexibility to add or retire measures from their programs unilaterally as markets, technology and evaluation results change. Therefore, Program Administrators are free to implement prescriptive measures that are not included in the TRM as long as such measures are submitted to the TRM update procedure. Similarly, Program Administrators are not required to implement every measure that is included in the TRM.

## 3.4 Using the TRM to Calculate Savings

The TRM is intended to bring a high level of standardization to the measure savings that each Program Administrator (Utilities and DCEO) uses across the state. To accomplish the goal of statewide standardization, Program Administrators are required to use the prescriptive savings algorithms and input values that are provided in the TRM, subject to the following three exceptions.

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[15] Note that DCEO is also a Program Administrator who was enabled to operate programs by the energy efficiency legislation.

[16] As with all aspects of the TRM, this is true unless the Commission determines otherwise.

17 The TRM Administrator's role has not been firmly established, but its role as described herein has been reviewed and accepted by the SAG and Staff.

1. The measure savings are being calculated on a custom basis.

A Program Administrator can choose to implement a TRM measure as a custom measure. Just because a measure is in the TRM does not mean that a Program Administrator must calculate savings for that measure prescriptively. The Program Administrator may choose to implement a measure through its own custom program, calculate savings using actual or on-site parameter values. However, once a measure is implemented on a custom basis within a particular program, all instances of the measure within that program must be implemented on a custom basis. Also, prior to treating a TRM measure as a custom measure in a particular program, the Program Administrators will notify the TAC, and the treatment of the measure as a custom versus a prescriptive measure will be discussed during the TRM Update Procedure during the next update cycle.

2. The measure does not yet exist in the TRM.

In this case, the Program Administrator is free to use algorithms and/or input values that do not yet appear in the TRM after discussing the new measure with the TAC. The Program Administrator shall provide to the TAC and TRM Administrator the Components of the TRM Measure Characterization contained in Section 2.3, and also work papers in the approved format. The results will be subject to the usual evaluation and ICC review requirements, and the new measure must be submitted to the TRM Update Procedure during the next update cycle.

3. The TRM measure definition or prescriptive savings inputs do not correctly characterize a measure that is already implemented in an existing program.

Through the TRM development process, the TAC attempted to identify all of the measures that are currently being implemented in programs. The TAC also worked to ensure that the prescriptive savings inputs describe how the measure is being implemented in all of the current programs. However, the measures or prescriptive savings inputs in the TRM may differ from how the measure is actually being implemented in a particular program, especially over time as programs and markets evolve. If the TRM measure or prescriptive savings inputs do not match how a measures is implemented in an existing program, the utilities and DCEO may modify savings inputs as long as the TAC is notified of the change prior to the utility using the modified savings inputs, and the measure definition change and/or modified prescriptive inputs are submitted to the TRM Update Procedure during the next update cycle.

In cases where the Program Administrator feels that it has a strong and documented case for calculating the prescriptive measure savings based on its own prescriptive savings inputs and algorithms that differs from prescriptive savings inputs and algorithms contained in the TRM, it must first submit its case to the TAC with the measure characterization and work papers and to the TRM Update Procedure for possible inclusion in a subsequent version of the TRM. For example, the Program Administrator may have undertaken a new evaluation study that provides a new parameter value that is better supported or more applicable to the local conditions.

For Cases 1 – 3 above, the utilities will present for comment to the TAC prior to using a value that is not in the TRM, and also submit the alternate value to the TRM Update Procedure during the next update cycle. At least ten (10) business prior to presenting Cases 1 – 3 to the TAC, the Program Administrator shall submit to the TRM Administrator and the SAG Facilitator the measure characterization and work papers in the approved work paper format so that the TAC has adequate time to meaningfully review and comment on the proposed variation to the TRM applicability. Furthermore, utilities bear retrospective risk if the ICC does not agree with measure values, including prescriptive savings inputs, used by the utilities that differ from what is in the TRM.

## 3.4.1 TRM Mistakes

If significant mistake is found in the TRM that results in an unreasonable savings estimate, the Program Administrator(s), Evaluator, TRM Administrator, and SAG will strive to reach consensus on a solution that will result in a reasonable savings estimate. For example, an unreasonable savings estimate may result from an error

or omission in the TRM, or an assumption in the TRM that is found to differ significantly from actual program findings.  In only these limited cases where there is consensus that the TRM contains a significant mistake will TRM updates occur within a program year and outside of the TRM update schedule defined in Section 4.

In these limited cases, Evaluators will use corrected TRM algorithms and inputs to calculate energy and capacity savings. Otherwise, errors found in the TRM will be officially corrected through the annual TRM Update Process. Program Administrators should provide sufficient justification for using the alternate solution within a memo to the SAG/TAC for comment prior to using the alternate measure or prescriptive savings assumption. This documentation will also be used for the TRM update process.

## 3.5   The TRM's Relationship to Portfolio Evaluation

Program Administrators will update their tracking systems and other program delivery systems to collect and track appropriate data needed to support TRM application. Program Administrators, with input from the TAC, will collaborate with Evaluators prior to the start of each program year to define data collection to support TRM application and updating, while minimizing unnecessary cost and burden on Program Administrators, Evaluators and customers.    However, Evaluators are not obligated to support TRM updating if such work is not within the Evaluator's budget or would compromise their primary goal of measuring portfolio and program savings verification.

Evaluators shall perform savings verification (see glossary section) and present  savings estimates based on TRM values within the evaluation reports of the Utilities' and DCEO's energy efficiency portfolios. Evaluators shall perform net-to-gross research consistent with utility orders. Additionally, where possible based on available budgets, the Evaluators may also perform measure and/or program level research (see glossary section). Savings verification values and, where present, measure or program level research shall be provided in the annual independent evaluation report required pursuant to 220 ILCS 5/8-103(f)(7) and 220 ILCS 5/8-104(f)(8), although each will be presented in separate sections of the report. Evaluation results for each Utility will be applied in accordance with the ICC Orders approving that Utility's energy efficiency plan.

For savings verification, evaluators will estimate energy and capacity savings for prescriptive measures as the product of participants, quantities, net-to-gross ratios, and unit savings.

- Evaluators will verify participants and installed quantities, consistent with approaches defined in Evaluator work plans.
- Evaluators will apply net-to-gross ratios consistent with the net-to-gross policies defined in ICC Orders approving Utility Energy Efficiency Plans.
- Evaluators will calculate unit savings for prescriptive measures included in the TRM using applicable TRM algorithms, deemed values, and default values, using the following approach and schedule:
  - For savings achieved in EPY4/GPY1, Evaluators will apply unit savings included in Utilities' approved Energy Efficiency Plans.
  - For savings achieved in EPY5/GPY2, Evaluators will apply savings based on the initial TRM approved by the ICC; and
  - For savings achieved in future Program Years, Evaluators will apply values based on the TRM Update finalized by March 31 prior to the start of the Program Year.

For any measures not included in the TRM, including custom measures, prescriptive measures not yet incorporated into the TRM, and prescriptive measures Program Administrators choose to implement using custom savings calculations, Evaluators will develop appropriate savings calculations, consistent with policy direction provided in ICC Orders and Evaluator Work Plans.

## 3.6   The TRM's Relationship to Portfolio Planning

The most current TRM that is filed with the Commission each program year shall be used in the preparation of the Utilities' and DCEO's energy efficiency plans.  The Utilities and DCEO are permitted to use additional assumptions other than those contained within the TRM in their Plan filings, provided they include a description of why they believe deviation from the TRM is appropriate (e.g., a particular measure may be in the process of getting updated in the TRM at that time).

Program Administrators adding new prescriptive measures to their portfolios must submit these measures for possible inclusion in future TRM updates. The TRM Administrator and SAG will identify appropriate measures to include in future TRM Updates, using the process identified in Section 4.

There are no specific requirements for Program Administrators to complete annual or other shorter term plans. Because Evaluators will apply TRM algorithms to calculate prescriptive measure savings and cost effectiveness, Program Administrators will use TRM algorithms and savings values when preparing any shorter term plans to manage their Energy Efficiency portfolios.

# 4  TRM Update Process & Timeline

Because technology is constantly improving, and markets are constantly changing, a TRM must be a living document to keep pace with change.  Otherwise, the TRM will quickly become obsolete and the savings estimates will become inaccurate.  The need to update the TRM can be driven by a number of events, including but not limited to, the following:

- •  Addition of new measure algorithms perceived to be reliable for TRM inclusion
- •  Impact of code or legislative changes to specific measures
- •  Introduction of new technologies
- •  Discovery of errors in existing TRM measure characterizations
- •  Changes to industry standard practice

The following sections outline the annual TRM Update Process, including roles and responsibilities for stakeholders in the TRM Update Process and a timeline for updating the TRM that is in sequence with the regulatory milestones that have already been set for future efficiency Plan filings.  In addition, the TAC will continue to meet on a monthly basis, with additional meetings, if needed, to discuss the applicability of the TRM, any situations where a utility believes the TRM value should not apply as a condition set forth in Section 3.4, above, exists, any TRM mistakes, and any other matters relating to the TRM.

## 4.1  Stakeholder Roles and Responsibilities

Formal recommendations for TRM changes should be submitted along with all supporting work papers consistent with the approved Work Paper format to the SAG Technical Advisory Committee (TAC) and TRM Administrator, concurrently. Although any party is free to recommend changes to the TRM, there are a set of stakeholders for which responsibilities can be specified (as shown below), and these responsibilities are officially adopted by the Commission upon approval of this TRM.

1. **Evaluators** (Evaluation Teams, Independent Consultants) – The Evaluators have primary responsibility pursuant to 220 ILCS 5/8-103(f)(7) and 220 ILCS 5/8-104(f)(8) to provide independent evaluations of the performance of the Utilities' and DCEO's energy efficiency portfolios. To support this responsibility in the context of the TRM, Evaluators will perform savings verification to calculate savings for prescriptive measures covered by the TRM, and, where budget allows, conduct measure and program level research to inform future TRM updates. The Evaluators shall collaborate with the Utilities, the SAG TAC, and DCEO to determine appropriate data collection and analysis that supports TRM savings verification updates, where available budget exists, while considering the administrative cost and participant burden associated with such data collection.

2. **ICC Staff** – Whose primary responsibility is to make recommendations to the Commission, participate in the development in the annual TRM compliance filing and participate in the SAG's TRM Technical Advisory Committee (TAC).

3. **Illinois Commerce Commission** (ICC or Commission or Regulator) – Who receives the TRM annually as a joint filing from the Program Administrators, and may at its own discretion, approve, modify, or deny proposed input or algorithmic changes to the TRM.

4. **Illinois Energy Efficiency Stakeholder Advisory Group**[18] (SAG) – The Illinois Energy Efficiency Stakeholder Advisory Group is advised of and given the opportunity to comment on the TRM Administrator's recommended TRM Updates prior to the revised (redlined) TRM being filed with the ICC. However, technical issues regarding the TRM are usually addressed substantively through the TAC, which is open to any SAG participant.

5. **Program Administrator** (Utilities and DCEO) – The Utilities and DCEO have primary responsibility to cost effectively meet the energy savings targets defined by Illinois statute by implementing energy efficiency programs. The Utilities and DCEO are also responsible for tracking program participation, reporting estimates of energy savings using TRM values, where such values exist, estimating cost effectiveness, and implementing the TRM savings values through their tracking systems. The Utilities, the TAC and DCEO collaborate with the Evaluators prior to the start of each program year to determine an appropriate balance of data collection necessary to update the TRM in the upcoming program year while considering the administrative cost and participant burden associated with such data collection. The Utilities, DCEO, and the TAC make recommendations for TRM Updates.

6. **SAG Technical Advisory Committee** (TAC) – The TAC is a subcommittee of the SAG whose primary responsibility is to provide a forum to allow all interested parties to recommend TRM updates, additions, and changes and facilitate consensus for TRM changes among the Evaluators, ICC Staff, Utilities, DCEO, portfolio administrators, program implementers, interested stakeholders (e.g., SAG participants), and the TRM Administrator prior to the annual TRM Update proceeding. All recommendations for TRM changes shall be submitted to the TRM Technical Advisory Committee and TRM Administrator concurrently. Where consensus does not emerge in the SAG TAC regarding a particular TRM change, the SAG provides a forum where experts on all sides of the contested issue can present their expert opinions in an effort to inform parties of the contested issue and to also facilitate consensus. Any documents filed with the ICC will reflect any areas where consensus is not reached through a "Comparison Exhibit" that sets forth the different expert opinions on a particular issue or matter.

7. **TRM Administrator** (Independent Consultant) – The TRM Administrator has primary responsibilities to manage changes to the TRM document, present to the SAGTAC, coordinate with the SAG, serve as an independent technical resource, and if desired by the SAG, manage a publicly accessible TRM website that contains TRM-related documents such as references, recommendations, responses, and versions of the TRM. The TRM Administrator reviews and responds[19] to all formal TRM recommendations by a date specified in advance by the TRM Administrator, when updating the TRM for a specific program year. The TRM Administrator prepares the revised TRM document (redlined) each year for filing with the ICC based on recommended TRM changes vetted through the SAG TAC and the large-group SAG. The TRM Administrator shall make any necessary revisions to the TRM to reflect the Commission Order from the annual TRM Update proceeding.

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[18] The Commission defined the SAG to include "… the Utility, DCEO, Staff, the Attorney General, BOMA and CUB and representation from a variety of interests, including residential consumers, business consumers, environmental and energy advocacy organizations, trades and local government... [and] a representative from the ARES (alternative retail electric supplier) community should be included." http://www.ilsag.org/home

[19] The TRM Administrator's "response" to a formal recommendation for a TRM change shall explain whether the TRM Administrator agrees with the formal recommendation (either in its entirety or as modified by the TRM Administrator) and the justification for the TRM Administrator's recommendation.

**Table 4.1: Specific Responsibilities of Each Stakeholder in the TRM Update Procedure**

| Role | Change Existing Measure (1)[20] | Create New Measures (2) |
|---|---|---|
| **Evaluator** (Consultant) | • Provides reviews of savings algorithms, inputs and program designs.<br>• Offers an opinion on other parties' recommendation, including potential modifications.<br>• Identifies and recommends changes as part of the annual evaluations.<br>• Provides recommendations to the SAG Technical Advisory Committee and TRM Administrator.<br>• Identifies and recommends changes based on ongoing reviews of measures and markets.<br>• Coordinates with other Program Administrators' evaluation teams. | • Offers am opinion on other parties' recommendations, including potential modificaiton.<br>• Provides recommendations to the SAG Technical Advisory Committee and TRM Administrator.<br>• Coordinates with other Program Administrators' evaluation teams. |
| **ICC** (Regulator) | • At its discretion, the ICC may approve, modify or deny requests for TRM input and algorithm assumptions or how the TRM is applied. | • At its discretion, the ICC may approve, modify or deny requests for TRM input and algorithm assumptions or how the TRM is applied. |
| **ICC Staff** | • Make recommendations to approve, modify or deny requests for TRM input and algorithm assumptions or how the TRM is applied. | • Make recommendations to approve, modify or deny requests for TRM input and algorithm assumptions or how the TRM is applied. |
| **Illinois Energy Efficiency Stakeholder Advisory Group[21]** (SAG) | • Provides an open forum where changes to existing measures may be discussed.<br>• Is informed of all proposed changes to the TRM by the TAC. | • Provides an open forum where changes to existing measures may be discussed.<br>• Is informed of all proposed changes to the TRM by the TAC. |

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[20] In the event that a measure must be retired, this general category and are not listed separately as a result.

[21] The Commission defined the SAG to include "… the Utility, DCEO, Staff, the Attorney General, BOMA and CUB and representation from a variety of interests, including residential consumers, business consumers, environmental and energy advocacy organizations, trades and local government... [and] a representative from the ARES (alternative retail electric supplier) community should be included." http://www.ilsag.org/home

| Role | Change Existing Measure (1)[20] | Create New Measures (2) |
|---|---|---|
| **Program Administrator** (Utilities & DCEO) | • Updates its tracking systems and modifies its measure calculations, and provides measure update recommendations.<br>• Provides recommendations to the SAG Technical Advisory Committee and TRM Administrator.<br>• Facilitates review process with Evaluator, other Program Administrators and their evaluation teams, if necessary. | • Updates its tracking systems and provides new measure recommendations.<br>• Defines the algorithm and conducts the sensitivity analysis.<br>• Provides recommendations to the SAG Technical Advisory Committee and TRM Administrator.<br>• Facilitates review process with Evaluator, other Program Administrators and their evaluation teams, if necessary. |
| **TRM Administrator** (Independent Consultant) | • Manages the TRM.<br>• Facilitates and reviews recommendations from other parties as part of the TRM Technical Advisory Committee forum.<br>• Acts as an independent technical resource to the SAG/TAC. | • Manages the TRM.<br>• Facilitates and reviews recommendations from other parties as part of the TRM Technical Advisory Committee forum.<br>• Acts as an independent technical resource to the SAG/TAC. |
| **SAG Technical Advisory Committee** (TAC) | • May recommend changes, updates or additions to the TRM<br>• Coordinates with utilities, DCEO and Evaluators on data collection through evaluation that would be useful in updating the TRM, while being mindful of resource constraints and customer burden.<br>• Provides a forum to facilitate consensus for the recommended changes. | • May recommend changes, updates or additions to the TRM<br>• Coordinates with utilities, DCEO and Evaluators on data collection through evaluation that would be useful in updating the TRM, while being mindful of resource constraints and customer burden.<br>• Provides a forum to facilitate consensus for the new measure. |

## 4.2 The Regulatory Schedule for Energy Efficiency Programs

Because technology and markets are so dynamic, a structured and ongoing update process for the TRM is necessary. Because the update process needs to be aligned with Illinois' existing program planning and implementation cycles, these cycles are summarized in the following two tables.

**Table 4.2: Efficiency Plan Periods**

| Cycle | Plan Filing Date | Electric Plan Approval | Applicable Electric Program Year (PY) | Applicable Gas Program Year[22] (PY) |
|---|---|---|---|---|
| 1 | Nov-07 | Feb-08 | PY1 – PY3 | |
| 2 | Oct-10 | Dec-10 | PY4 – PY6 | PY1 – PY3 |
| 3 | Sep-13 | Feb-14 | PY7 – PY9 | PY4 – PY6 |

**Table 4.3: TRM Implementation Cycle[23]**

| Cycle | EPY | GPY | Begins | Ends | Application in Evaluation | Application in 3-Year Plans |
|---|---|---|---|---|---|---|
| 1 | 1 | | 6/1/2008 | 5/31/2009 | TRM does not apply to this cycle. | TRM not used in this cycle |
| 1 | 2 | | 6/1/2009 | 5/31/2010 | | |
| 1 | 3 | | 6/1/2010 | 5/31/2011 | | |
| 2 | 4 | 1 | 6/1/2011 | 5/31/2012 | TRM does not apply to this PY | TRM not used in this cycle |
| 2 | 5 | 2 | 6/1/2012 | 5/31/2013 | TRM finalized by 6/1/12 applies | |
| 2 | 6 | 3 | 6/1/2013 | 5/31/2014 | TRM finalized by 3/1/13 applies | |
| 3 | 7 | 4 | 6/1/2014 | 5/31/2015 | TRM finalized by 3/1/14 applies | TRM finalized by 3/1/13 used in filing; TRM finalized by 3/1/14. |
| 3 | 8 | 5 | 6/1/2015 | 5/31/2016 | TRM finalized by 3/1/15 applies | |
| 3 | 9 | 6 | 6/1/2016 | 5/31/2017 | TRM finalized by 3/1/16 applies | |

## 4.3 Update Timeline and Process

The process of incorporating new and better information into the TRM occurs annually. Prior to the start of the program year for which the Updated TRM will be in effect, the Utilities and DCEO will make portfolio adjustments and tracking system updates based in part on changes reflected in the Updated TRM. Thus, efforts will be made to have the Updated TRM approved by the Commission by March 1st of each program year to provide the Utilities and DCEO adequate time for making these pre-program year changes.

The evaluation results from one program year will be put into effect for the first time at the beginning of the next planning year. However, it should be noted that it is appropriate and expected that any completed evaluation be considered and/or incorporated into the TRM as they become available.

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[22] Note that there is no statutory deadline for the approval of gas efficiency plans.

[23] It is assumed the prospective application of the March 1 TRM will occur continuously until policy dictates otherwise. In the spirit of collaboration and support of the TRM process and due to the current 2012 transition process of completing the TRM, there will be an exception to the March 1 dating where TRM results that are finalized as of June 1, 2012 will be in effect for the evaluation of PY5.

**Figure 1: Timeline and Milestones of the TRM Update Procedure**

| Year | Month | Elec PY's / Gas PY's | PY4 / PY1 | PY5 / PY2 | PY6 / PY3 | PY7 / PY4 |
|---|---|---|---|---|---|---|
| 2012 | Jan | ● | | | | |
| | Feb | | | | | |
| | Mar | 1st TRM | | | | |
| | Apr | | | | | |
| | May | ● | | | | |
| | Jun | | | | | |
| | Jul | | | | | |
| | Aug | | | ★ | | |
| | Sep | | | | | |
| | Oct | | | | | |
| | Nov | | | ▲ | | |
| | Dec | | | | | |
| 2013 | Jan | | | ⬡ | | |
| | Feb | | | | | |
| | Mar | | | ◆ | | |
| | Apr | | | | | |
| | May | | | ● | | |
| | Jun | | | | | |
| | Jul | | | | | |
| | Aug | | | | ★ | |
| | Sep | | | | | |
| | Oct | | | | | |
| | Nov | | | | ▲ | |
| | Dec | | | | | |
| 2014 | Jan | | | | ⬡ | |
| | Feb | | | | | |
| | Mar | | | | ◆ | |
| | Apr | | | | | |
| | May | | | | ● | |
| | Jun | | | | | |
| | Jul | | | | | |
| | Aug | | | | | ★ |
| | Sep | | | | | |
| | Oct | | | | | |
| | Nov | | | | | ▲ |
| | Dec | | | | | |

| Legend | |
|---|---|
| Statewide TRM Development | ● |
| Finalize Portfolio Reporting | ★ |
| Draft Evaluation Report | ▲ |
| Collaborative Update Process | ⬇ |
| Final Evaluation Report | ⬡ |
| TRM Update Complete | ◆ |
| Finalize TRM Values | ● |
| Results Feed Into Updated TRM | ⤴ |

**Figure 2: Timeline & Process Flow of the TRM Update Procedure by Stakeholder**
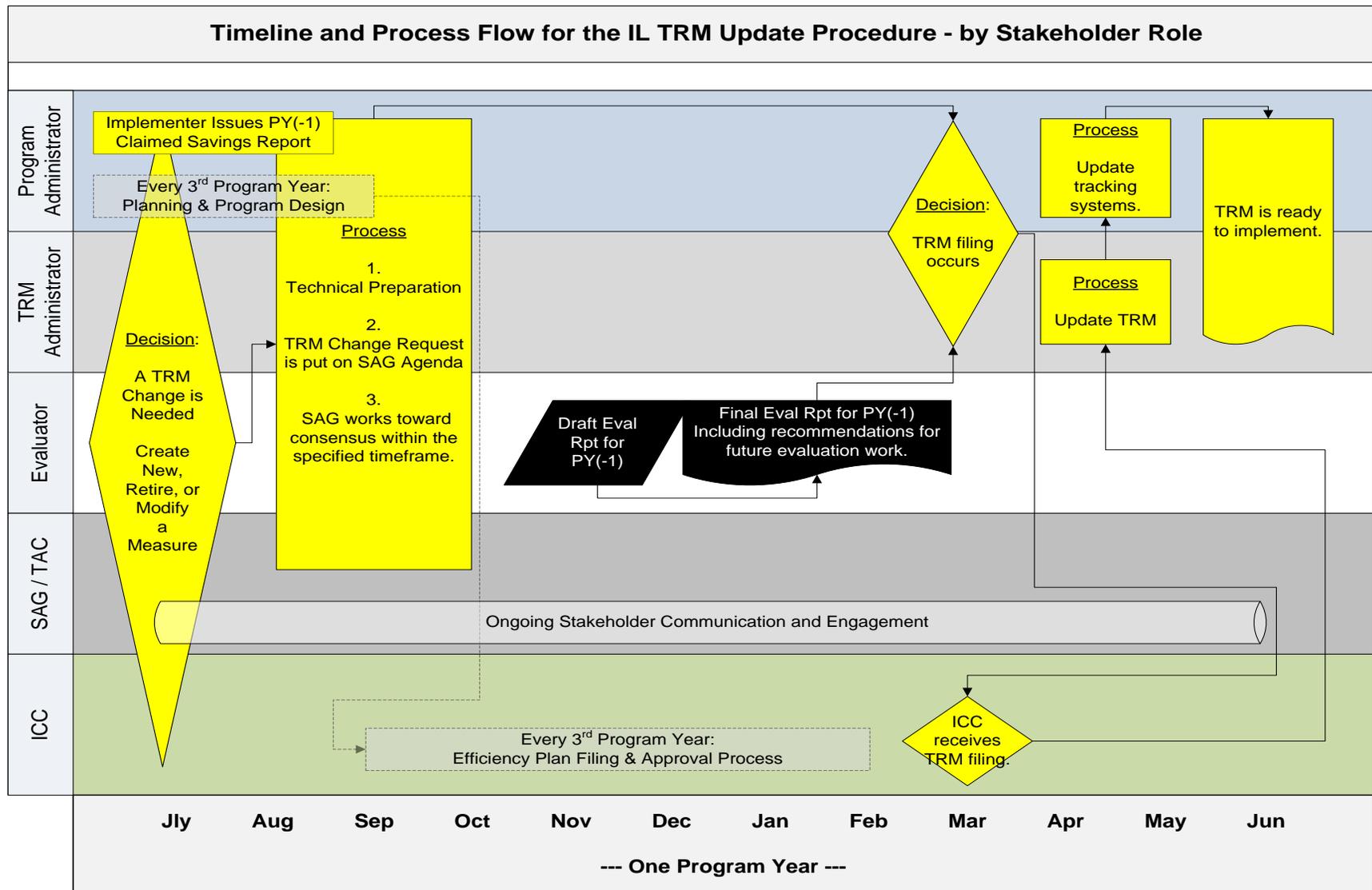
# 5 Assumptions

The information contained in this TRM contains VEIC's recommendations for the content of the Illinois TRM. Sources that are cited within the TRM have been chosen based on two priorities, geography and age. Whenever possible and appropriate, VEIC has incorporated Illinois-specific information into each measure characterization. The Business TRM documents from Ameren and ComEd were reviewed, as well as program and measure specific data from evaluations, efficiency plans, and working documents.

The assumptions for these characterizations rest on our understanding of the information available. In each case, the available Illinois and Midwest-specific information was reviewed, including evaluations and support material provided by the Illinois Utilities.

When Illinois or region-specific evaluations or data were not available, best practice research and data from other jurisdictions was used, often from west and east-coast states that have allocated large amounts of funding to evaluation work and to refining their measure characterization parameters. As a result, much of the most-defensible information originates from these regions. In every case, VEIC used the most recent, well-designed, and best-supported studies and only if it was appropriate to generalize their conclusions to the Illinois programs.

## 5.1 Footnotes & Documentation of Sources

Each measure characterization uses footnotes to document the references that have been used to characterize the technology. The reference documents are too numerous to include in an Appendix and have instead been posted in *.zip files on the TRM's Sharepoint website. These zip files can be found in the 'Sources and Reference Documents' folder in the main directory, and will also be posted to the SAG's public web site (www.ilsag.org) as well.

## 5.2 General Savings Assumptions

The TRM savings estimates are expected to serve as average, representative 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.

- All estimates of energy (kWh) and peak (kW) savings are for first-year savings, not lifetime savings.

- 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, they represent the average energy (kWh or therms) or peak (kW) savings that could be expected from the average of all measures that might be installed in Illinois in the program year.

- In general, the baselines included in the TRM are intended to represent average conditions in Illinois. 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 Illinois data are not available.

## 5.3 Shifting Baseline Assumptions

The TRM anticipates the effects of changes in efficiency codes and standards on affected measures. When these changes take effect, a shift in the baseline is usually required. This complicates the measure savings estimation somewhat, and will be handled in future versions of the TRM by describing the choice of and reasoning behind a

shifting baseline assumption.  In this version of the TRM, this applies to CFLs and T12 Linear Fluorescents.

## 5.3.1   CFL and T5/T8 Linear Fluorescents

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. Federal legislation (stemming from the Energy Independence and Security Act of 2007) mandates a phase-in process beginning in 2012 for 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 and 40W bulbs in 2014. The baseline for the CFL measure in the corresponding program years starting June 1 each year will therefore become bulbs (improved or "efficient" incandescent, or halogen) that meet the new standard and have the same lumen equivalency. 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. To account for this shifting baseline, annual savings are reduced within the lifetime of the measure.

Other lighting measures will also have baseline shifts (for example screw based LED and CFL fixtures) that will result in significant impacts to annual estimated savings in later years.  Finally, as of July 14, 2012, Federal Standards will require that practically all linear fluorescents meet strict performance requirements essentially requiring all T12 users, when they need to purchase new bulbs, to upgrade to high performance T8 lamps and ballasts[24].  We have assumed that this standard will become fully effective in 2016.  To account for this, we have included a methodology to address the shifting baseline in the high performance T8 measure and T5 measure which is defined specifically in each measure characterization.

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[24] At the time of this draft, we understand that some standard T8 lamps may meet the federal standard, and in that event, some T12 retrofits may end up being completed with standard T8s instead of high performance T8s.

## 5.4   Glossary

**Baseline Efficiency:** The assumed standard efficiency of equipment, absent an efficiency program.

**Building Types[25]:**

| Building Type | Definition |
| --- | --- |
| College/University | Applies to facility space used for higher education. Relevant buildings include administrative headquarters, residence halls, athletic and recreation facilities, laboratories, etc. The total gross floor area should include all supporting functions such as kitchens used by staff, lobbies, atria, conference rooms and auditoria, fitness areas for staff, storage areas, stairways, elevator shafts, etc. |
| Exterior | Applies to unconditioned spaces that are outside of the building envelope. |
| Garage | Applies to unconditioned spaces either attached or detached from the primary building envelope that are not used for living space. |
| Grocery | Applies to facility space used for the retail sale of food and beverage products. It should not be used by restaurants, which are not eligible for a rating at this time. The total gross floor area should include all supporting functions such as kitchens and break rooms used by staff, storage areas (refrigerated and non-refrigerated), administrative areas, stairwells, atria, lobbies, etc. |
| Heavy and Light Industry | Applies to buildings that are decidated to manufacuturing activities.  Light industry buildings are characterized by consumer product and component manufacturing while Heavy industry buildings are characterized by products that require full assumbly under closely regulated conditions.  These building types may be distinguished by categorizing NIACS (SIC) codes according to the needs of the Program Administrator, but are generally similar in terms of their energy performance and operating characteristics. |
| Hotel/Motel | Applies to buildings that rent overnight accommodations on a room/suite basis, typically including a bath/shower and other facilities in guest rooms.  The total gross floor area should include all interior space, including guestrooms, halls, lobbies, atria, food preparation and restaurant space, conference and banquet space, health clubs/spas, indoor pool areas, and laundry facilities, as well as all space used for supporting functions such as elevator shafts, stairways, mechanical rooms, storage areas, employee break rooms, back-of-house offices, etc.  Hotel does not apply to fractional ownership properties such as condominiums or vacation timeshares.  Hotel properties should be owned by a single entity and have rooms available on a nightly basis. |
| K-12 School | Applies to facility space used as a school building for Kindergarten through 12th grade students. This does not include college or university classroom facilities and laboratories, vocational, technical, or trade schools. The total gross floor area should include all supporting functions such as administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoria, laboratory classrooms, portable classrooms,  greenhouses, stairways, atria, elevator shafts, small landscaping sheds, storage areas, etc.  The K-12 school model does not apply to preschool or day care buildings; in order to classify as K-12 school, more than 75% of the students must be in kindergarten or older. |
| Medical | Applies to a general medical and surgical hospital (including critical access hospitals and children's hospitals) that is either a stand-alone building or a campus of buildings. |

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[25] Source: US EPA, www.energystar.gov, Space Type Definitions

| Building Type | Definition |
|---|---|
|  | The definition of Hospital accounts for all space types that are located within the Hospital building/campus, such as medical offices, administrative offices, and skilled nursing.  The total floor area should include the aggregate floor area of all buildings on the campus as well as all supporting functions such as: stairways, connecting corridors between buildings, medical offices, exam rooms, laboratories, lobbies, atria, cafeterias, storage areas, elevator shafts, and any space affiliated with emergency medical care, or diagnostic care. |
| Miscellaneous | Applies tospaces that do not fit clearly within any available categories should be designated as "miscellaneous". |
| Multifamily | Applies to residential buildings of three of more units, including all public and multiuse spaces within the building envelope. |
| Office | Applies to facility spaces used for general office, professional, and administrative purposes. The total gross floor area should include all supporting functions such as kitchens used by staff, lobbies, atria, conference rooms and auditoria, fitness areas for staff, storage areas, stairways, elevator shafts, etc. |
| Restaurant | Applies to a subcategory of Retail/Service space that is used to provide commercial food services to individual customers, and includes kitchen, dining, and common areas. |
| Retail/Service | Applies to facility space used to conduct the retail sale of consumer product goods.  Stores must be at least 5,000 square feet and have an exterior entrance to the public. The total gross floor area should include all supporting functions such as kitchens and break rooms used by staff, storage areas, administrative areas, elevators, stairwells, etc. Retail segments typically included under this definition are: Department Stores, Discount Stores, Supercenters, Warehouse Clubs, Drug Stores, Dollar Stores, Home Center/Hardware Stores, and Apparel/Hard Line Specialty Stores (e.g. books, clothing, office products, toys, home goods, electronics). Retail segments excluded under this definition are: Supermarkets (eligible to be benchmarked as Supermarket space), Convenience Stores, Automobile Dealerships, and Restaurants. |
| Warehouse | Applies to unrefrigerated or refrigerated buildings that are used to store goods, manufactured products, merchandise or raw materials. The total gross floor area of Refrigerated Warehouses should include all temperature controlled area designed to store perishable goods or merchandise under refrigeration at temperatures below 50 degrees Fahrenheit. The total gross floor area of Unrefrigerated Warehouses should include space designed to store non-perishable goods and merchandise. Unrefrigerated warehouses also include distribution centers. The total gross floor area of refrigerated and unrefrigerated warehouses should include all supporting functions such as offices, lobbies, stairways, rest rooms, equipment storage areas, elevator shafts, etc. Existing atriums or areas with high ceilings should only include the base floor area that they occupy. The total gross floor area of refrigerated or unrefrigerated warehouse should not include outside loading bays or docks. Self-storage facilities, or facilities that rent individual storage units, are not eligible for a rating using the warehouse model. |

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

**Commercial & Industrial:** The market sector that includes measures that apply to any of the building types defined

in this TRM, which includes multifamily common areas and public housing[26].

**Connected Load**: The maximum wattage of the equipment, under normal operating conditions.

**Deemed Value:** A value that has been assumed to be representative of the average condition of an input parameter. This term may also refer to the calculated result of a prescriptive savings algorithm.

**Default Value**: When a measure indicates that an input to a prescriptive saving algorithm may take on a range of values, an average value is also provided in many cases. This value is considered the default input to the algorithm, and should be used when the other alternatives listed in the measure are not applicable.

**End-use Category:** A general term used to describe the categories of equipment that provide a service to an individual or building. See Table 2.1 for a list of the end-use categories that are incorporated in this TRM.

**EM&V –** Evaluation, Measurement and Verification. An ongoing annual process that Program Administrators must complete for the ICC.

**Evaluation:** Evaluation is an applied inquiry process for collecting and synthesizing evidence that culminates in conclusions about the state of affairs, accomplishments, value, merit, worth, significance, or quality of a program, product, person, policy, proposal, or plan. Evaluation in the energy efficiency arena is an investigation process to determine energy or demand impacts achieved through the program activities, encompassing, but not limited to: *savings verification*, *measure level research*, and *program level research*. Additionally, evaluation may occur outside of the bounds of this TRM structure to assess the design and implementation of the program.

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

**High Efficiency**: General term for technologies and processes that require less energy, water, or other inputs to operate.

**Lifetime**: The number of years (or hours) that the new high efficiency equipment is expected to function. These are generally based on engineering lives, but sometimes adjusted based on expectations about frequency of removal, remodeling or demolition. Two important distinctions fall under this definition; Effective Useful Life (EUL) and Remaining Useful Life (RUL).

> **EUL** – EUL is based on the manufacturers rating of the effective useful life; how long the equipment will last. For example, a CFL that operates x hours per year will typically have an EUL of y. A house boiler may have a lifetime of 20 years but the EUL is only 15 years since after that time it may be operating at a non-efficient point. An estimate of the median number of years that the measures installed under a program are still in place and operable.

> **RUL** – Applies to retrofit or replacement measures. For example, if an existing working refrigerator is replaced with a high efficiency unit, the RUL is an assumption of how many more years the existing unit would have lasted. As a general rule the RUL is usually assumed to be 1/3 of the EUL.

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

**Measure Cost**: The incremental (for time of sale measures) or full cost (both capital and labor for retrofit

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[26] Measures that apply to the multifamily and public housing building types describe how to handle tenant versus master metered buildings.

measures) of implementing the High Efficiency equipment.

**Measure Description**: A detailed description of the technology and the criteria it must meet to be eligible for as an energy efficient measure.

**Measure Type:** Measures are categorized into two subcategories; prescriptive and custom.

> **Custom:** Measures that use an energy savings algorithm and/or inputs, or metering results that apply only to the individual customer who is implementing them.

> **Prescriptive:** Measures whose energy savings algorithm and inputs are fixed within the TRM and may not be changed by the Program Administrator. Prescriptive measures make up most of the measure in the Residential market sector. Two subcategories of prescriptive measures include:

> > **Fully Deemed:** A measure whose inputs are completely specified and are not subject to change or choice on the part of the Program Administrator.

> > **Partially Deemed:** A measure whose inputs may be selected to some degree by the Program Administrator.

**Measure:** An efficient technology or procedure that results in energy savings as compared to the baseline efficiency.

**Measure Level Research**: An evaluation process that takes a deeper look into measure level savings achieved through program activities driven by the goal of providing Illinois-specific research to facilitate updating measure specific TRM input values or algorithms. The focus of this process will primarily be driven by measures with high savings within utility portfolios, measures with high uncertainty in TRM input values or algorithms (typically informed by previous savings verification activities or program level research), or measures where the TRM is lacking Illinois-specific, current or relevant data.

**Program Level Research**: An evaluation process that takes an alternate look into achieved program level savings across multiple measures. This type of research may or may not be specific enough to inform future TRM updates because it is done at the program level rather than measure level. An example of such research would be a program billing analysis.

**Residential:** The market sector that includes measures that apply only to detached, residential buildings or duplexes.

**Operation and Maintenance (O&M) Cost Adjustments:** The dollar impact resulting from differences between baseline and efficient case Operation and Maintenance costs.

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

**Program:** The mode of delivering a particular measure or set of measures to customers. See Table 2.4 for a list of program descriptions that are presently operating in Illinois.

**Rating Period Factor** (RPF): Percentages for defined times of the year that describe when energy savings will be realized for a specific measure.

**Savings Verification**: An evaluation process that independently verifies program savings achieved through Prescriptive Measures. This process verifies that the TRM was applied correctly and consistently by the program being investigated, that the measure level inputs to the algorithm were correct, and that the quantity of measures claimed through the program are correct and in place and operating. The results of savings verification may be

expressed as a program savings realization rate (verified ex post savings / claimed ex ante savings). Savings verification may also result in recommendations for further evaluation and/or field (metering) studies to increase the accuracy of the TRM savings estimate going forward.

**Stakeholder Advisory Group (SAG):** The Illinois Energy Efficiency Stakeholder Advisory Group (SAG) was first defined in the electric utilities' first energy efficiency Plan Orders to include "… the Utility, DCEO, Staff, the Attorney General, BOMA and CUB and representation from a variety of interests, including residential consumers, business consumers, environmental and energy advocacy organizations, trades and local government... [and] a representative from the ARES (alternative retail electric supplier) community should be included."[27]   A group of stakeholders who have an interest in Illinois' energy efficiency programs and who meet regularly to share information and work toward consensus on various energy efficiency issues.  The Utilities in Illinois have been directed by the Illinois Commerce Commission (ICC) to work with the SAG on the development of a statewide TRM. A list of current SAG participants appears in the following table.

**Table 5.1: SAG Stakeholder List**

| SAG Stakeholder |
| --- |
| Ameren Illinois Company (Ameren) |
| Center for Neighborhood Technology (CNT) |
| Citizen's Utility Board (CUB) |
| City of Chicago |
| Commonwealth Edison Company (ComEd) |
| Environment IL |
| Environmental Law and Policy Center (ELPC) |
| Future Energy Enterprises LLC |
| Illinois Commerce Commission Staff (ICC Staff) |
| Illinois Department of Commerce and Economic Opportunity (DCEO) |
| Illinois Attorney General's Office (AG) |
| Integrys (Peoples Gas and North Shore Gas) |
| Metropolitan Mayor's Caucus (MMC) |
| Midwest Energy Efficiency Association (MEEA) |
| National Resources Defense Council (NRDC) |
| Nicor Gas |
| Shaw Environmental |
| Energy Resources Center at the University of Illinois, Chicago (ERC) |

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[27] Docket No. 07-0540, Final Order at 32-33, February 6, 2008.
http://www.icc.illinois.gov/downloads/public/edocket/215193.pdf

## 5.5   Electrical Loadshapes (kWh)

Loadshapes are an integral part of the measure characterization and are used to divide energy savings into appropriate periods using Rating Period Factors (RPFs) such that each have variable avoided cost values allocated to them for the purpose of estimating cost effectiveness.

For the purposes of assigning energy savings (kWh) periods, the TRM TAC has agreed to use the industry standards for wholesale power market transactions as shown in the following table.

**Table 2.4: On and Off Peak Energy Definitions**

| Period Category | Period Definition (Central Prevailing Time) |
|---|---|
| Winter On-Peak Energy | 8AM - 11PM, weekday, Oct - Apr, No NERC holidays |
| Winter Off-Peak Energy | All other hours |
| Summer On-Peak Energy | 8AM - 11PM, weekdays, May – Sept, No NERC holidays |
| Summer Off-Peak Energy | All other hours |

Loadshapes have been developed for each end-use by assigning Rating Period Factor percentages to each of the four periods above. Two methodologies were used:

1.  Itron eShapes[28] data for Missouri, reconciled to Illinois loads and provided by Ameren, were used to calculate the percentage of load in to the four categories above.

2.  Where the Itron eShapes data did not provide a particular end-use or specific measure load profile, loadshapes that have been developed over many years by Efficiency Vermont and that have been reviewed by the Vermont Department of Public Service, were adjusted to match Illinois period definitions. Note – no weather sensitive loadshapes were based on this method. Any of these load profiles that relate to High Impact Measures should be an area of future evaluation.

The following pages provide the loadshape values for all measures provided in the TRM. To distinguish the source of the loadshape, they are color coded.  Rows that are shaded in green are Efficiency Vermont loadshapes adjusted for Illinois periods.  Rows that are unshaded and are left in white are Itron eShapes data provided by Ameren.

The Illinois electric utilities use the DSMore™ (Integral Analytics DSMore™ Demand Side Management Option/Risk Evaluator) software to screen the efficiency measures for cost effectiveness. Since this tool requires a loadshape value for weekdays and weekends in each month (i.e., 24 inputs), the percentages for the four period categories above were calculated by weighting the proportion of weekdays/weekends in each month to the total within each period. The results of these calculations are also provided below.

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[28] All loadshape information has been posted to the project's Sharepoint site, and may be provided publically through the Stakeholder Advisory Group's web site at their discretion.  http://www.ilsag.org/

**Table 5.2: Loadshapes by Season**

| | Loadshape Reference Number | Winter Peak | Winter Off-peak | Summer Peak | Summer Off-peak |
|---|---|---|---|---|---|
| | | Oct-Apr, M-F, non-holiday, 8AM - 11PM | Oct-Apr, All other time | May- Sept, M-F, non-holiday, 8AM - 11PM | May - Sept, All other time |
| Residential Clothes Washer | R01 | 47.0% | 11.1% | 34.0% | 8.0% |
| Residential Dish Washer | R02 | 49.3% | 8.7% | 35.7% | 6.3% |
| Residential Electric DHW | R03 | 43.2% | 20.6% | 24.5% | 11.7% |
| Residential Freezer | R04 | 38.9% | 16.4% | 31.5% | 13.2% |
| Residential Refrigerator | R05 | 37.0% | 18.1% | 30.1% | 14.7% |
| Residential Indoor Lighting | R06 | 48.1% | 15.5% | 26.0% | 10.5% |
| Residential Outdoor Lighting | R07 | 18.0% | 44.1% | 9.4% | 28.4% |
| Residential Cooling | R08 | 4.1% | 0.7% | 71.3% | 23.9% |
| Residential Electric Space Heat | R09 | 57.8% | 38.8% | 1.7% | 1.7% |
| Residential Electric Heating and Cooling | R10 | 35.2% | 22.8% | 31.0% | 11.0% |
| Residential Ventilation | R11 | 25.8% | 32.3% | 18.9% | 23.0% |
| Residential - Dehumidifier | R12 | 12.9% | 16.2% | 31.7% | 39.2% |
| Residential Standby Losses - Entertainment Center | R13 | 26.0% | 32.5% | 18.9% | 22.6% |
| Residential Standby Losses - Home Office | R14 | 23.9% | 34.6% | 17.0% | 24.5% |
| | | | | | |
| Commercial Electric Cooking | C01 | 40.6% | 18.2% | 28.7% | 12.6% |
| Commercial Electric DHW | C02 | 40.5% | 18.2% | 28.5% | 12.8% |
| Commercial Cooling | C03 | 4.9% | 0.8% | 66.4% | 27.9% |
| Commercial Electric Heating | C04 | 53.5% | 43.2% | 1.9% | 1.4% |
| Commercial Electric Heating and Cooling | C05 | 19.4% | 13.5% | 47.1% | 19.9% |
| Commercial Indoor Lighting | C06 | 40.1% | 18.6% | 28.4% | 12.9% |
| Grocery/Conv. Store Indoor Lighting | C07 | 31.4% | 26.4% | 22.8% | 19.3% |
| Hospital Indoor Lighting | C08 | 29.1% | 29.0% | 21.0% | 20.9% |
| Office Indoor Lighting | C09 | 42.1% | 16.0% | 30.4% | 11.5% |
| Restaurant Indoor Lighting | C10 | 32.1% | 25.7% | 23.4% | 18.8% |

| | Loadshape Reference Number | Winter Peak Oct-Apr, M-F, non-holiday, 8AM - 11PM | Winter Off-peak Oct-Apr, All other time | Summer Peak May- Sept, M-F, non-holiday, 8AM - 11PM | Summer Off-peak May - Sept, All other time |
|---|---|---|---|---|---|
| Retail Indoor Lighting | C11 | 35.5% | 22.3% | 25.8% | 16.3% |
| Warehouse Indoor Lighting | C12 | 39.4% | 18.5% | 28.6% | 13.5% |
| K-12 School Indoor Lighting | C13 | 45.8% | 22.6% | 20.2% | 11.4% |
| Indust. 1-shift (8/5) (e.g., comp. air, lights) | C14 | 50.5% | 7.2% | 37.0% | 5.3% |
| Indust. 2-shift (16/5) (e.g., comp. air, lights) | C15 | 47.5% | 10.2% | 34.8% | 7.4% |
| Indust. 3-shift (24/5) (e.g., comp. air, lights) | C16 | 34.8% | 23.2% | 25.5% | 16.6% |
| Indust. 4-shift (24/7) (e.g., comp. air, lights) | C17 | 25.8% | 32.3% | 18.9% | 23.0% |
| Industrial Indoor Lighting | C18 | 44.3% | 13.6% | 32.4% | 9.8% |
| Industrial Outdoor Lighting | C19 | 18.0% | 44.1% | 9.4% | 28.4% |
| Commercial Outdoor Lighting | C20 | 23.4% | 35.3% | 13.0% | 28.3% |
| Commercial Office Equipment | C21 | 37.7% | 20.9% | 26.7% | 14.7% |
| Commercial Refrigeration | C22 | 38.5% | 20.6% | 26.7% | 14.2% |
| Commercial Ventilation | C23 | 38.1% | 20.6% | 29.7% | 11.6% |
| Traffic Signal - Red Balls, always changing or flashing | C24 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - Red Balls, changing day, off night | C25 | 37.0% | 20.9% | 27.1% | 14.9% |
| Traffic Signal - Green Balls, always changing | C26 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - Green Balls, changing day, off night | C27 | 37.0% | 20.9% | 27.1% | 14.9% |
| Traffic Signal - Red Arrows | C28 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - Green Arrows | C29 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - Flashing Yellows | C30 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - "Hand" Don't Walk Signal | C31 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - "Man" Walk Signal | C32 | 25.8% | 32.3% | 18.9% | 23.0% |
| Traffic Signal - Bi-Modal Walk/Don't Walk | C33 | 25.8% | 32.3% | 18.9% | 23.0% |
| Industrial Motor | C34 | 47.5% | 10.2% | 34.8% | 7.4% |
| Industrial Process | C35 | 47.5% | 10.2% | 34.8% | 7.4% |
| HVAC Pump Motor (heating) | C36 | 38.7% | 48.6% | 5.9% | 6.8% |
| HVAC Pump Motor (cooling) | C37 | 7.8% | 9.8% | 36.8% | 45.6% |

| | Loadshape Reference Number | Winter Peak<br>Oct-Apr, M-F, non-holiday, 8AM - 11PM | Winter Off-peak<br>Oct-Apr, All other time | Summer Peak<br>May- Sept, M-F, non-holiday, 8AM - 11PM | Summer Off-peak<br>May - Sept, All other time |
|---|---|---|---|---|---|
| HVAC Pump Motor (unknown use) | C38 | 23.2% | 29.2% | 21.4% | 26.2% |
| VFD - Supply fans <10 HP | C39 | 38.8% | 16.1% | 28.4% | 16.7% |
| VFD - Return fans <10 HP | C40 | 38.8% | 16.1% | 28.4% | 16.7% |
| VFD - Exhaust fans <10 HP | C41 | 34.8% | 23.2% | 20.3% | 21.7% |
| VFD - Boiler feedwater pumps <10 HP | C42 | 42.9% | 44.2% | 6.6% | 6.3% |
| VFD - Chilled water pumps <10 HP | C43 | 11.2% | 5.5% | 40.7% | 42.6% |
| VFD Boiler circulation pumps <10 HP | C44 | 42.9% | 44.2% | 6.6% | 6.3% |
| Refrigeration Economizer | C45 | 36.3% | 50.8% | 5.6% | 7.3% |
| Evaporator Fan Control | C46 | 24.0% | 35.9% | 16.7% | 23.4% |
| Standby Losses - Commercial Office | C47 | 8.2% | 50.5% | 5.6% | 35.7% |
| VFD Boiler draft fans <10 HP | C48 | 37.3% | 48.9% | 6.4% | 7.3% |
| VFD Cooling Tower Fans <10 HP | C49 | 7.9% | 5.2% | 54.0% | 32.9% |
| Engine Block Heater Timer | C50 | 26.5% | 61.0% | 4.1% | 8.5% |
| Door Heater Control | C51 | 30.4% | 69.6% | 0.0% | 0.0% |
| Beverage and Snack Machine Controls | C52 | 10.0% | 48.3% | 7.4% | 34.3% |
| Flat | C53 | 36.3% | 21.8% | 26.2% | 15.7% |

**Table 5.3: Loadshapes by Month and Day of Week**

| | | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S |
| Residential Clothes Washer | R01 | 7.0% | 1.6% | 6.3% | 1.5% | 6.6% | 1.7% | 6.7% | 1.5% | 6.9% | 1.6% | 6.5% | 1.6% | 7.1% | 1.5% | 6.8% | 1.7% | 6.6% | 1.6% | 7.0% | 1.5% | 6.5% | 1.7% | 6.9% | 1.6% |
| Residential Dish Washer | R02 | 7.3% | 1.2% | 6.6% | 1.2% | 7.0% | 1.4% | 7.1% | 1.2% | 7.3% | 1.2% | 6.9% | 1.3% | 7.4% | 1.2% | 7.1% | 1.3% | 7.0% | 1.2% | 7.4% | 1.2% | 6.8% | 1.3% | 7.2% | 1.3% |
| Residential Electric DHW | R03 | 6.4% | 2.9% | 5.8% | 2.7% | 6.1% | 3.3% | 6.2% | 2.8% | 5.0% | 2.3% | 4.7% | 2.4% | 5.1% | 2.2% | 4.9% | 2.5% | 4.8% | 2.3% | 6.5% | 2.8% | 6.0% | 3.1% | 6.3% | 3.0% |
| Residential Freezer | R04 | 5.8% | 2.3% | 5.2% | 2.2% | 5.5% | 2.6% | 5.6% | 2.2% | 6.4% | 2.6% | 6.1% | 2.7% | 6.6% | 2.5% | 6.3% | 2.8% | 6.1% | 2.6% | 5.8% | 2.2% | 5.4% | 2.4% | 5.7% | 2.4% |
| Residential Refrigerator | R05 | 5.5% | 2.6% | 4.9% | 2.4% | 5.2% | 2.9% | 5.3% | 2.5% | 6.2% | 2.9% | 5.8% | 3.0% | 6.3% | 2.8% | 6.0% | 3.1% | 5.9% | 2.9% | 5.5% | 2.5% | 5.1% | 2.7% | 5.4% | 2.6% |
| Residential Indoor Lighting | R06 | 7.1% | 2.2% | 6.4% | 2.1% | 6.8% | 2.4% | 6.9% | 2.1% | 5.3% | 2.1% | 5.0% | 2.2% | 5.4% | 2.0% | 5.2% | 2.2% | 5.1% | 2.1% | 7.2% | 2.1% | 6.6% | 2.3% | 7.0% | 2.2% |
| Residential Outdoor Lighting | R07 | 2.7% | 6.2% | 2.4% | 5.9% | 2.6% | 7.0% | 2.6% | 6.0% | 1.9% | 5.7% | 1.8% | 5.8% | 2.0% | 5.3% | 1.9% | 6.0% | 1.8% | 5.7% | 2.7% | 6.0% | 2.5% | 6.6% | 2.6% | 6.4% |
| Residential Cooling | R08 | 0.6% | 0.1% | 0.5% | 0.1% | 0.6% | 0.1% | 0.6% | 0.1% | 14.6% | 4.8% | 13.7% | 4.9% | 14.9% | 4.5% | 14.2% | 5.0% | 13.9% | 4.8% | 0.6% | 0.1% | 0.6% | 0.1% | 0.6% | 0.1% |
| Residential Electric Space Heat | R09 | 8.6% | 5.5% | 7.7% | 5.1% | 8.2% | 6.1% | 8.3% | 5.3% | 0.3% | 0.3% | 0.3% | 0.3% | 0.4% | 0.3% | 0.3% | 0.4% | 0.3% | 0.3% | 8.7% | 5.3% | 8.0% | 5.8% | 8.5% | 5.6% |
| Residential Electric Heating and Cooling | R10 | 5.2% | 3.2% | 4.7% | 3.0% | 5.0% | 3.6% | 5.0% | 3.1% | 6.3% | 2.2% | 6.0% | 2.3% | 6.5% | 2.1% | 6.2% | 2.3% | 6.0% | 2.2% | 5.3% | 3.1% | 4.9% | 3.4% | 5.2% | 3.3% |
| Residential Ventilation | R11 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Residential - Dehumidifier | R12 | 1.9% | 2.3% | 1.7% | 2.2% | 1.8% | 2.6% | 1.8% | 2.2% | 6.5% | 7.8% | 6.1% | 8.0% | 6.6% | 7.3% | 6.3% | 8.2% | 6.2% | 7.8% | 1.9% | 2.2% | 1.8% | 2.4% | 1.9% | 2.4% |
| Residential Standby Losses - Entertainment Center | R13 | 3.8% | 4.6% | 3.5% | 4.3% | 3.7% | 5.1% | 3.7% | 4.4% | 3.9% | 4.5% | 3.7% | 4.6% | 4.0% | 4.2% | 3.8% | 4.8% | 3.7% | 4.5% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Residential Standby Losses - Home Office | R14 | 3.5% | 4.9% | 3.2% | 4.6% | 3.4% | 5.5% | 3.4% | 4.7% | 3.5% | 4.9% | 3.3% | 5.0% | 3.5% | 4.6% | 3.4% | 5.2% | 3.3% | 4.9% | 3.6% | 4.7% | 3.3% | 5.2% | 3.5% | 5.0% |

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| | | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S |
| Commercial Electric Cooking | C01 | 6.0% | 2.6% | 5.4% | 2.4% | 5.7% | 2.9% | 5.8% | 2.5% | 5.9% | 2.5% | 5.5% | 2.6% | 6.0% | 2.4% | 5.7% | 2.6% | 5.6% | 2.5% | 6.1% | 2.5% | 5.6% | 2.7% | 5.9% | 2.6% |
| Commercial Electric DHW | C02 | 6.0% | 2.6% | 5.4% | 2.4% | 5.7% | 2.9% | 5.8% | 2.5% | 5.8% | 2.5% | 5.5% | 2.6% | 6.0% | 2.4% | 5.7% | 2.7% | 5.6% | 2.5% | 6.1% | 2.5% | 5.6% | 2.7% | 5.9% | 2.6% |
| Commercial Cooling | C03 | 0.7% | 0.1% | 0.6% | 0.1% | 0.7% | 0.1% | 0.7% | 0.1% | 13.6% | 5.5% | 12.8% | 5.7% | 13.9% | 5.2% | 13.3% | 5.9% | 13.0% | 5.5% | 0.7% | 0.1% | 0.7% | 0.1% | 0.7% | 0.1% |
| Commercial Electric Heating | C04 | 7.9% | 6.1% | 7.1% | 5.7% | 7.6% | 6.8% | 7.7% | 5.9% | 0.4% | 0.3% | 0.4% | 0.3% | 0.4% | 0.3% | 0.4% | 0.3% | 0.4% | 0.3% | 8.0% | 5.9% | 7.4% | 6.5% | 7.8% | 6.3% |
| Commercial Electric Heating and Cooling | C05 | 2.9% | 1.9% | 2.6% | 1.8% | 2.8% | 2.1% | 2.8% | 1.9% | 9.6% | 4.0% | 9.1% | 4.1% | 9.8% | 3.7% | 9.4% | 4.2% | 9.2% | 4.0% | 2.9% | 1.9% | 2.7% | 2.0% | 2.8% | 2.0% |
| Commercial Indoor Lighting | C06 | 5.9% | 2.6% | 5.3% | 2.5% | 5.7% | 2.9% | 5.7% | 2.6% | 5.8% | 2.6% | 5.5% | 2.6% | 5.9% | 2.4% | 5.7% | 2.7% | 5.5% | 2.6% | 6.0% | 2.6% | 5.5% | 2.8% | 5.9% | 2.7% |
| Grocery/Conv. Store Indoor Lighting | C07 | 4.7% | 3.7% | 4.2% | 3.5% | 4.4% | 4.2% | 4.5% | 3.6% | 4.7% | 3.8% | 4.4% | 3.9% | 4.8% | 3.6% | 4.6% | 4.1% | 4.5% | 3.8% | 4.7% | 3.6% | 4.3% | 3.9% | 4.6% | 3.8% |
| Hospital Indoor Lighting | C08 | 4.3% | 4.1% | 3.9% | 3.8% | 4.1% | 4.6% | 4.2% | 4.0% | 4.3% | 4.2% | 4.0% | 4.3% | 4.4% | 3.9% | 4.2% | 4.4% | 4.1% | 4.2% | 4.4% | 4.0% | 4.0% | 4.3% | 4.3% | 4.2% |
| Office Indoor Lighting | C09 | 6.2% | 2.3% | 5.6% | 2.1% | 6.0% | 2.5% | 6.0% | 2.2% | 6.2% | 2.3% | 5.9% | 2.4% | 6.4% | 2.2% | 6.1% | 2.4% | 5.9% | 2.3% | 6.3% | 2.2% | 5.8% | 2.4% | 6.2% | 2.3% |
| Restaurant Indoor Lighting | C10 | 4.8% | 3.6% | 4.3% | 3.4% | 4.5% | 4.1% | 4.6% | 3.5% | 4.8% | 3.7% | 4.5% | 3.8% | 4.9% | 3.5% | 4.7% | 4.0% | 4.6% | 3.7% | 4.8% | 3.5% | 4.4% | 3.8% | 4.7% | 3.7% |
| Retail Indoor Lighting | C11 | 5.3% | 3.1% | 4.7% | 3.0% | 5.0% | 3.5% | 5.1% | 3.1% | 5.3% | 3.2% | 5.0% | 3.3% | 5.4% | 3.1% | 5.2% | 3.4% | 5.0% | 3.2% | 5.3% | 3.1% | 4.9% | 3.3% | 5.2% | 3.2% |
| Warehouse Indoor Lighting | C12 | 5.8% | 2.6% | 5.2% | 2.5% | 5.6% | 2.9% | 5.6% | 2.5% | 5.8% | 2.7% | 5.5% | 2.8% | 6.0% | 2.5% | 5.7% | 2.8% | 5.6% | 2.7% | 5.9% | 2.5% | 5.4% | 2.8% | 5.8% | 2.7% |
| K-12 School Indoor Lighting | C13 | 6.8% | 3.2% | 6.1% | 3.0% | 6.5% | 3.6% | 6.6% | 3.1% | 4.1% | 2.3% | 3.9% | 2.3% | 4.2% | 2.1% | 4.0% | 2.4% | 3.9% | 2.3% | 6.9% | 3.1% | 6.3% | 3.4% | 6.7% | 3.3% |
| Indust. 1-shift (8/5) (e.g., comp. air, lights) | C14 | 7.5% | 1.0% | 6.7% | 1.0% | 7.1% | 1.1% | 7.2% | 1.0% | 7.5% | 1.1% | 7.1% | 1.1% | 7.7% | 1.0% | 7.4% | 1.1% | 7.2% | 1.1% | 7.6% | 1.0% | 7.0% | 1.1% | 7.4% | 1.0% |

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| | | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S |
| Indust. 2-shift (16/5) (e.g., comp. air, lights) | C15 | 7.0% | 1.4% | 6.3% | 1.4% | 6.7% | 1.6% | 6.8% | 1.4% | 7.1% | 1.5% | 6.7% | 1.5% | 7.3% | 1.4% | 6.9% | 1.6% | 6.8% | 1.5% | 7.1% | 1.4% | 6.6% | 1.5% | 7.0% | 1.5% |
| Indust. 3-shift (24/5) (e.g., comp. air, lights) | C16 | 5.1% | 3.3% | 4.6% | 3.1% | 4.9% | 3.7% | 5.0% | 3.2% | 5.2% | 3.3% | 4.9% | 3.4% | 5.3% | 3.1% | 5.1% | 3.5% | 5.0% | 3.3% | 5.2% | 3.2% | 4.8% | 3.5% | 5.1% | 3.4% |
| Indust. 4-shift (24/7) (e.g., comp. air, lights) | C17 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Industrial Indoor Lighting | C18 | 6.6% | 1.9% | 5.9% | 1.8% | 6.3% | 2.1% | 6.3% | 1.9% | 6.6% | 1.9% | 6.2% | 2.0% | 6.8% | 1.8% | 6.5% | 2.0% | 6.3% | 1.9% | 6.6% | 1.9% | 6.1% | 2.0% | 6.5% | 2.0% |
| Industrial Outdoor Lighting | C19 | 2.7% | 6.2% | 2.4% | 5.9% | 2.6% | 7.0% | 2.6% | 6.0% | 1.9% | 5.7% | 1.8% | 5.8% | 2.0% | 5.3% | 1.9% | 6.0% | 1.8% | 5.7% | 2.7% | 6.0% | 2.5% | 6.6% | 2.6% | 6.4% |
| Commercial Outdoor Lighting | C20 | 3.5% | 5.0% | 3.1% | 4.7% | 3.3% | 5.6% | 3.3% | 4.8% | 2.7% | 5.6% | 2.5% | 5.8% | 2.7% | 5.3% | 2.6% | 5.9% | 2.5% | 5.6% | 3.5% | 4.8% | 3.2% | 5.3% | 3.4% | 5.1% |
| Commercial Office Equipment | C21 | 5.6% | 3.0% | 5.0% | 2.8% | 5.3% | 3.3% | 5.4% | 2.9% | 5.4% | 2.9% | 5.1% | 3.0% | 5.6% | 2.7% | 5.3% | 3.1% | 5.2% | 2.9% | 5.6% | 2.9% | 5.2% | 3.1% | 5.5% | 3.0% |
| Commercial Refrigeration | C22 | 5.7% | 2.9% | 5.1% | 2.7% | 5.4% | 3.2% | 5.5% | 2.8% | 5.5% | 2.8% | 5.1% | 2.9% | 5.6% | 2.7% | 5.3% | 3.0% | 5.2% | 2.8% | 5.8% | 2.8% | 5.3% | 3.1% | 5.6% | 3.0% |
| Commercial Ventilation | C23 | 5.6% | 2.9% | 5.1% | 2.7% | 5.4% | 3.3% | 5.4% | 2.8% | 6.1% | 2.3% | 5.7% | 2.4% | 6.2% | 2.2% | 5.9% | 2.4% | 5.8% | 2.3% | 5.7% | 2.8% | 5.3% | 3.1% | 5.6% | 3.0% |
| Traffic Signal - Red Balls, always changing or flashing | C24 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Traffic Signal - Red Balls, changing day, off night | C25 | 5.5% | 2.9% | 4.9% | 2.8% | 5.2% | 3.3% | 5.3% | 2.9% | 5.5% | 3.0% | 5.2% | 3.1% | 5.7% | 2.8% | 5.4% | 3.1% | 5.3% | 3.0% | 5.5% | 2.9% | 5.1% | 3.1% | 5.4% | 3.0% |
| Traffic Signal - Green Balls, always changing | C26 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |

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| | | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S |
| Traffic Signal - Green Balls, changing day, off night | C27 | 5.5% | 2.9% | 4.9% | 2.8% | 5.2% | 3.3% | 5.3% | 2.9% | 5.5% | 3.0% | 5.2% | 3.1% | 5.7% | 2.8% | 5.4% | 3.1% | 5.3% | 3.0% | 5.5% | 2.9% | 5.1% | 3.1% | 5.4% | 3.0% |
| Traffic Signal - Red Arrows | C28 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Traffic Signal - Green Arrows | C29 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Traffic Signal - Flashing Yellows | C30 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Traffic Signal - "Hand" Don't Walk Signal | C31 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Traffic Signal - "Man" Walk Signal | C32 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Traffic Signal - Bi-Modal Walk/Don't Walk | C33 | 3.8% | 4.6% | 3.4% | 4.3% | 3.6% | 5.1% | 3.7% | 4.4% | 3.8% | 4.6% | 3.6% | 4.7% | 3.9% | 4.3% | 3.8% | 4.8% | 3.7% | 4.6% | 3.9% | 4.4% | 3.6% | 4.8% | 3.8% | 4.7% |
| Industrial Motor | C34 | 7.0% | 1.4% | 6.3% | 1.4% | 6.7% | 1.6% | 6.8% | 1.4% | 7.1% | 1.5% | 6.7% | 1.5% | 7.3% | 1.4% | 6.9% | 1.6% | 6.8% | 1.5% | 7.1% | 1.4% | 6.6% | 1.5% | 7.0% | 1.5% |
| Industrial Process | C35 | 7.0% | 1.4% | 6.3% | 1.4% | 6.7% | 1.6% | 6.8% | 1.4% | 7.1% | 1.5% | 6.7% | 1.5% | 7.3% | 1.4% | 6.9% | 1.6% | 6.8% | 1.5% | 7.1% | 1.4% | 6.6% | 1.5% | 7.0% | 1.5% |
| HVAC Pump Motor (heating) | C36 | 5.7% | 6.9% | 5.2% | 6.4% | 5.5% | 7.7% | 5.5% | 6.6% | 1.2% | 1.4% | 1.1% | 1.4% | 1.2% | 1.3% | 1.2% | 1.4% | 1.2% | 1.4% | 5.8% | 6.6% | 5.3% | 7.3% | 5.7% | 7.1% |
| HVAC Pump Motor (cooling) | C37 | 1.2% | 1.4% | 1.0% | 1.3% | 1.1% | 1.5% | 1.1% | 1.3% | 7.5% | 9.1% | 7.1% | 9.3% | 7.7% | 8.5% | 7.3% | 9.6% | 7.2% | 9.1% | 1.2% | 1.3% | 1.1% | 1.5% | 1.1% | 1.4% |
| HVAC Pump Motor (unknown use) | C38 | 3.4% | 4.1% | 3.1% | 3.9% | 3.3% | 4.6% | 3.3% | 4.0% | 4.4% | 5.2% | 4.1% | 5.4% | 4.5% | 4.9% | 4.3% | 5.5% | 4.2% | 5.2% | 3.5% | 4.0% | 3.2% | 4.4% | 3.4% | 4.2% |
| VFD - Supply fans <10 HP | C39 | 5.7% | 2.3% | 5.2% | 2.1% | 5.5% | 2.5% | 5.6% | 2.2% | 5.8% | 3.3% | 5.5% | 3.4% | 5.9% | 3.1% | 5.7% | 3.5% | 5.5% | 3.3% | 5.8% | 2.2% | 5.4% | 2.4% | 5.7% | 2.3% |
| VFD - Return fans <10 HP | C40 | 5.7% | 2.3% | 5.2% | 2.1% | 5.5% | 2.5% | 5.6% | 2.2% | 5.8% | 3.3% | 5.5% | 3.4% | 5.9% | 3.1% | 5.7% | 3.5% | 5.5% | 3.3% | 5.8% | 2.2% | 5.4% | 2.4% | 5.7% | 2.3% |
| VFD - Exhaust fans <10 HP | C41 | 5.1% | 3.3% | 4.6% | 3.1% | 4.9% | 3.7% | 5.0% | 3.2% | 4.1% | 4.3% | 3.9% | 4.4% | 4.2% | 4.1% | 4.1% | 4.6% | 4.0% | 4.3% | 5.2% | 3.2% | 4.8% | 3.5% | 5.1% | 3.4% |

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| | | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S | M-F | S-S |
| VFD - Boiler feedwater pumps <10 HP | C42 | 6.4% | 6.2% | 5.7% | 5.9% | 6.1% | 7.0% | 6.1% | 6.0% | 1.3% | 1.3% | 1.3% | 1.3% | 1.4% | 1.2% | 1.3% | 1.3% | 1.3% | 1.3% | 6.4% | 6.0% | 5.9% | 6.6% | 6.3% | 6.4% |
| VFD - Chilled water pumps <10 HP | C43 | 1.7% | 0.8% | 1.5% | 0.7% | 1.6% | 0.9% | 1.6% | 0.8% | 8.3% | 8.5% | 7.8% | 8.7% | 8.5% | 8.0% | 8.1% | 8.9% | 7.9% | 8.5% | 1.7% | 0.8% | 1.6% | 0.8% | 1.6% | 0.8% |
| VFD Boiler circulation pumps <10 HP | C44 | 6.4% | 6.2% | 5.7% | 5.9% | 6.1% | 7.0% | 6.1% | 6.0% | 1.3% | 1.3% | 1.3% | 1.3% | 1.4% | 1.2% | 1.3% | 1.3% | 1.3% | 1.3% | 6.4% | 6.0% | 5.9% | 6.6% | 6.3% | 6.4% |
| Refrigeration Economizer | C45 | 5.4% | 7.2% | 4.8% | 6.7% | 5.1% | 8.0% | 5.2% | 7.0% | 1.1% | 1.5% | 1.1% | 1.5% | 1.2% | 1.4% | 1.1% | 1.5% | 1.1% | 1.5% | 5.4% | 7.0% | 5.0% | 7.6% | 5.3% | 7.4% |
| Evaporator Fan Control | C46 | 3.6% | 5.1% | 3.2% | 4.8% | 3.4% | 5.7% | 3.4% | 4.9% | 3.4% | 4.7% | 3.2% | 4.8% | 3.5% | 4.4% | 3.3% | 4.9% | 3.3% | 4.7% | 3.6% | 4.9% | 3.3% | 5.4% | 3.5% | 5.2% |
| Standby Losses - Commercial Office | C47 | 1.2% | 7.1% | 1.1% | 6.7% | 1.2% | 8.0% | 1.2% | 6.9% | 1.1% | 7.1% | 1.1% | 7.3% | 1.2% | 6.7% | 1.1% | 7.5% | 1.1% | 7.1% | 1.2% | 6.9% | 1.1% | 7.5% | 1.2% | 7.3% |
| VFD Boiler draft fans <10 HP | C48 | 5.5% | 6.9% | 5.0% | 6.5% | 5.3% | 7.7% | 5.3% | 6.7% | 1.3% | 1.5% | 1.2% | 1.5% | 1.3% | 1.4% | 1.3% | 1.5% | 1.2% | 1.5% | 5.6% | 6.7% | 5.2% | 7.3% | 5.5% | 7.1% |
| VFD Cooling Tower Fans <10 HP | C49 | 1.2% | 0.7% | 1.1% | 0.7% | 1.1% | 0.8% | 1.1% | 0.7% | 11.0% | 6.5% | 10.4% | 6.7% | 11.3% | 6.2% | 10.8% | 6.9% | 10.5% | 6.5% | 1.2% | 0.7% | 1.1% | 0.8% | 1.2% | 0.8% |
| Engine Block Heater Timer | C50 | 3.9% | 8.6% | 3.5% | 8.1% | 3.7% | 9.6% | 3.8% | 8.3% | 0.8% | 1.7% | 0.8% | 1.7% | 0.8% | 1.6% | 0.8% | 1.8% | 0.8% | 1.7% | 4.0% | 8.3% | 3.7% | 9.1% | 3.9% | 8.9% |
| Door Heater Control | C51 | 4.5% | 9.8% | 4.0% | 9.2% | 4.3% | 11.0% | 4.3% | 9.5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 4.5% | 9.5% | 4.2% | 10.4% | 4.4% | 10.1% |
| Beverage and Snack Machine Controls | C52 | 1.5% | 6.8% | 1.3% | 6.4% | 1.4% | 7.6% | 1.4% | 6.6% | 1.5% | 6.8% | 1.4% | 7.0% | 1.5% | 6.4% | 1.5% | 7.2% | 1.4% | 6.8% | 1.5% | 6.6% | 1.4% | 7.2% | 1.5% | 7.0% |
| Flat | C53 | 5.4% | 3.1% | 4.8% | 2.9% | 5.1% | 3.4% | 5.2% | 3.0% | 5.3% | 3.1% | 5.0% | 3.2% | 5.5% | 2.9% | 5.2% | 3.3% | 5.1% | 3.1% | 5.4% | 3.0% | 5.0% | 3.3% | 5.3% | 3.2% |

## 5.6 Summer Peak Period Definition (kW)

To estimate the impact that an efficiency measure has on a utility's system peak, the peak itself needs to be defined. Illinois spans two different electrical control areas, the Pennsylvania – Jersey – Maryland (PJM) and the Midwest Independent System Operators (MISO). As a result, there is some disparity in the peak definition across the state. However, only PJM has a forward capacity market where an efficiency program can potentially participate. Because ComEd is part of the PJM control area, their definition of summer peak is being applied statewide in this TRM.

Because Illinois is a summer peaking state, only the summer peak period is defined for the purpose of this TRM. The coincident summer peak period is defined as 1:00-5:00 PM Central Prevailing Time on non-holiday weekdays, June through August.

Summer peak coincidence factors can be found within each measure characterization. The source is provided and is based upon evaluation results, analysis of load shape data (e.g., the Itron eShapes data provided by Ameren), or through a calculation using stated assumptions.

For measures that are not weather-sensitive, the summer peak coincidence factor is estimated whenever possible as the average of savings within the peak period defined above. For weather sensitive measures such as cooling, the summer peak coincidence factor is provided in two different ways. The first method is to estimate demand savings during the utility's peak hour (as provided by Ameren). This is likely to be the most indicative of actual peak benefits. The second way represents the average savings over the summer peak period, consistent with the non-weather sensitive end uses, and is presented so that savings can be bid into PJM's Forward Capacity Market.

## 5.7 Heating and Cooling Degree-Day Data

Many measures are weather sensitive. Because there is a range of climactic conditions across the state, VEIC engaged the Utilities to provide their preferences for what airports and cities are the best proxies for the weather in their service territories. The result of this engagement is in the table below. All of the data represents 30-year normals[29] from the National Climactic Data Center (NCDC). Note that the base temperature for the calculation of heating degree-days in this document does not follow the historical 65F degree base temperature convention. Instead VEIC used several different temperatures in this TRM to more accurately reflect the outdoor temperature when a heating or cooling system turns on.

Residential heating is based on 60F, in accordance with regression analysis of heating fuel use and weather by state by the Pacific Northwest National Laboratory[30]. Residential cooling is based on 65F in agreement with a field study in Wisconsin[31]. These are lower than typical thermostat set points because internal gains such as appliances, lighting, and people provide some heating. In C&I settings, internal gains are often much higher; the base temperatures for both heating and cooling is 55F[32]. Custom degree-days with building specific base temperatures are recommended for large C&I projects.

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[29] 30-year normals have been used instead of Typical Meteorological Year (TMY) data due to the fact that few of the measures in the TRM are significantly affected by solar insolation, which is one of the primary benefits of using the TMY approach.

[30] Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.

[31] Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p. 32 (amended in 2010).

[32] This value is based upon experience, and it is preferable to use building-specific base temperatures when available.

**Table 5.4: Degree-Day Zones and Values by Market Sector**

| Zone | Residential | | C&I | | Weather Station / City |
|---|---|---|---|---|---|
| | HDD | CDD | HDD | CDD | |
| 1 | 5,352 | 820 | 4,272 | 2,173 | Rockford AP / Rockford |
| 2 | 5,113 | 842 | 4,029 | 3,357 | Chicago O'Hare AP / Chicago |
| 3 | 4,379 | 1,108 | 3,406 | 2,666 | Springfield #2 / Springfield |
| 4 | 3,378 | 1,570 | 2,515 | 3,090 | Belleville SIU RSCH / Bellville |
| 5 | 3,438 | 1,370 | 2,546 | 2,182 | Carbondale Southern IL AP / Marion |
| Average | 4,860 | 947 | 3,812 | 3,051 | Weighted by occupied housing units |
| Base Temp | 60F | 65F | 55F | 55F | 30 year climate normals, 1981-2010 |

This table assigns each of the proxy cities to one of five climate zones. The following graphics from the Illinois State Water Survey show isobars (lines of equal degree-days) and we have color-coded the counties in each of these graphics using those isobars as a dividing line. Using this approach, the state divides into five cooling degree-day zones and five heating degree-day zones. Note that although the heating and cooling degree-day maps are similar, they are not the same, and the result is that there are a total of 10 climate zones in the state. The counties are listed in the tables following the figures for ease of reference.

**Figure 3: Cooling Degree-Day Zones by County**
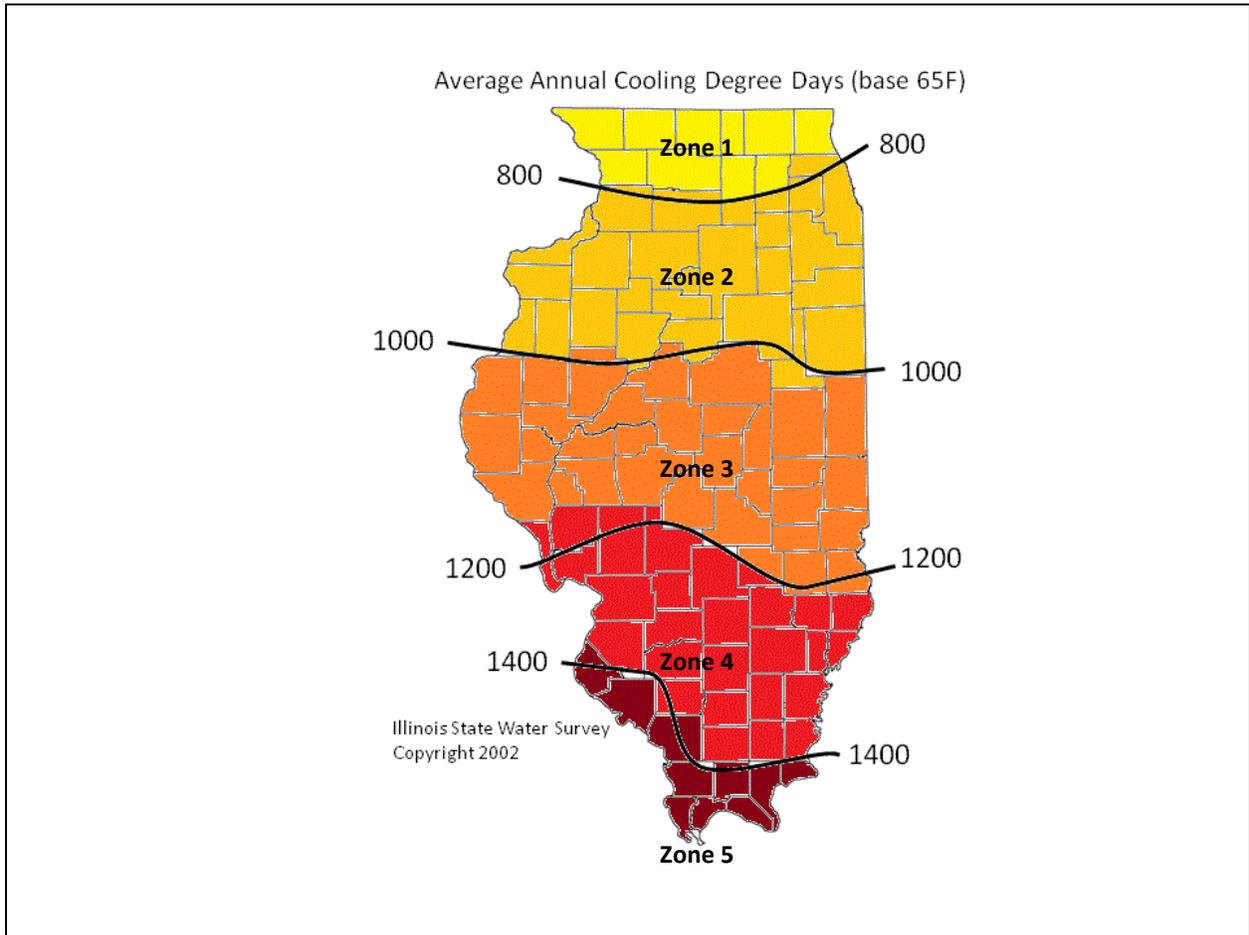
**Figure 4: Heating Degree-Day Zones by County**
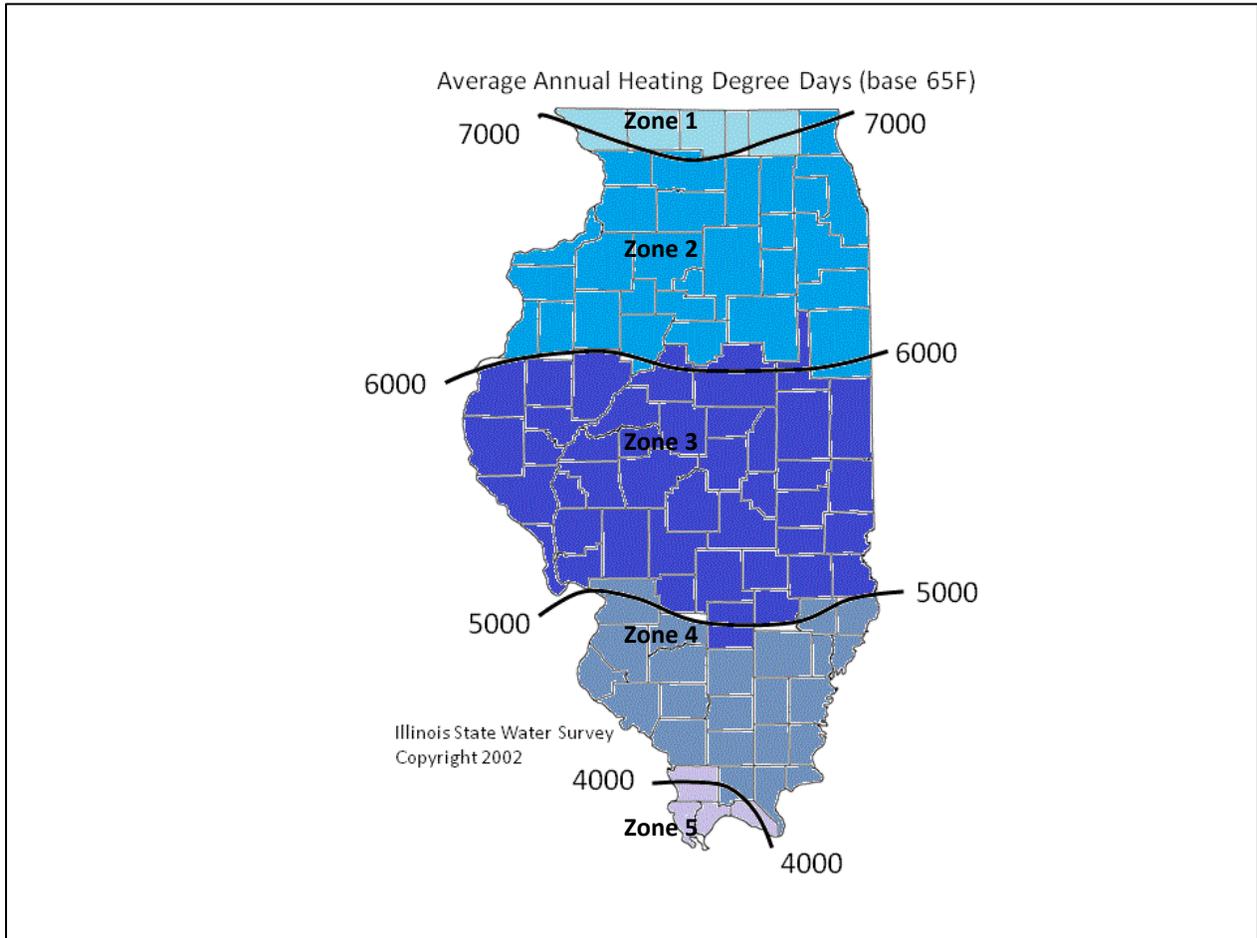
**Table 5.5: Heating Degree-Day Zones by County**

| Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 |
|---|---|---|---|---|
| Boone County | Carroll County | Adams County | Clinton County | Alexander County |
| Jo Daviess County | Bureau County | Bond County | Edwards County | Massac County |
| Stephenson County | Cook County | Brown County | Franklin County | Pulaski County |
| Winnebago County | DeKalb County | Calhoun County | Gallatin County | Union County |
| | DuPage County | Cass County | Hamilton County | |
| | Grundy County | Champaign County | Hardin County | |
| | Henderson County | Christian County | Jackson County | |
| | Henry County | Clark County | Jefferson County | |
| | Iroquois County | Clay County | Johnson County | |
| | Kane County | Coles County | Lawrence County | |
| | Kankakee County | Crawford County | Madison County | |
| | Kendall County | Cumberland County | Marion County | |
| | Knox County | De Witt County | Monroe County | |
| | Lake County | Douglas County | Perry County | |
| | LaSalle County | Edgar County | Pope County | |
| | Lee County | Effingham County | Randolph County | |
| | Livingston County | Fayette County | Richland County | |
| | Marshall County | Ford County | Saline County | |
| | McHenry County | Fulton County | St. Clair County | |
| | Mercer County | Greene County | Wabash County | |
| | Ogle County | Hancock County | Washington County | |
| | Peoria County | Jasper County | Wayne County | |
| | Putnam County | Jersey County | White County | |
| | Rock Island County | Logan County | Williamson County | |
| | Stark County | Macon County | | |
| | Warren County | Macoupin County | | |
| | Whiteside County | Mason County | | |
| | Will County | McDonough County | | |
| | Woodford County | McLean County | | |
| | | Menard County | | |
| | | Montgomery | | |
| | | Morgan County | | |
| | | Moultrie County | | |
| | | Piatt County | | |
| | | Pike County | | |
| | | Sangamon County | | |
| | | Schuyler County | | |
| | | Scott County | | |
| | | Shelby County | | |
| | | Tazewell County | | |
| | | Vermilion County | | |

**Table 5.6: Cooling Degree-day Zones by County**

| Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 |
|--------|--------|--------|--------|--------|
| Boone County | Bureau County | Adams County | Bond County | Alexander County |
| Carroll County | Cook County | Brown County | Clay County | Hardin County |
| DeKalb County | DuPage County | Calhoun County | Clinton County | Johnson County |
| Jo Daviess County | Grundy County | Cass County | Edwards County | Massac County |
| Kane County | Henderson County | Champaign County | Fayette County | Pope County |
| Lake County | Henry County | Christian County | Franklin County | Pulaski County |
| McHenry County | Iroquois County | Clark County | Gallatin County | Randolph County |
| Ogle County | Kankakee County | Coles County | Hamilton County | Union County |
| Stephenson County | Kendall County | Crawford County | Jackson County | |
| Winnebago County | Knox County | Cumberland County | Jefferson County | |
| | LaSalle County | De Witt County | Jersey County | |
| | Lee County | Douglas County | Lawrence County | |
| | Livingston County | Edgar County | Macoupin County | |
| | Marshall County | Effingham County | Madison County | |
| | Mercer County | Ford County | Marion County | |
| | Peoria County | Fulton County | Monroe County | |
| | Putnam County | Greene County | Montgomery | |
| | Rock Island County | Hancock County | Perry County | |
| | Stark County | Jasper County | Richland County | |
| | Warren County | Logan County | Saline County | |
| | Whiteside County | Macon County | St. Clair County | |
| | Will County | Mason County | Wabash County | |
| | Woodford County | McDonough County | Washington County | |
| | | McLean County | Wayne County | |
| | | Menard County | White County | |
| | | Morgan County | Williamson County | |
| | | Moultrie County | | |
| | | Piatt County | | |
| | | Pike County | | |
| | | Sangamon County | | |
| | | Schuyler County | | |
| | | Scott County | | |
| | | Shelby County | | |
| | | Tazewell County | | |
| | | Vermilion County | | |

## 5.8   O&M Costs and the Weighted Average Cost of Capital (WACC)

Some measures specify an operations and maintenance (O&M) parameter that describes the incremental O&M cost savings that can be expected over the measure's lifetime.  When estimating the cost effectiveness of these measures, it is necessary to calculate the net present value (NPV) of O&M costs over the life of the measure, which requires an appropriate discount rate.  The utility's weighted average cost of capital (WACC) is the most commonly used discount rate that is used in this context.

Each utility has a unique WACC that will vary over time.  As a result, the TRM does not specify the NPV of the O&M costs.  Instead, the necessary information required to calculate the NPV is included.  An example is provided below to demonstrate how to calculate the NPV of O&M costs.

---

**EXAMPLE**

Baseline Case:      O&M costs equal $150 every two years.

Efficient Case:      O&M costs equal $50 every five years.

---

Given this information, the incremental O&M costs can be determined by discounting the cash flows in the Baseline Case and the Efficient Case separately using the applicable WACC.  Then the NPV of the incremental O&M costs is calculated by subtracting one NPV from the other.  This value is then used in each utility's cost-effectiveness screening process.

Those measures that include baseline shifts that result in multiple component costs and lifetimes cannot be calculated by this standard method. In only these cases, the O&M costs are presented both as Annual Levelized equivalent cost (i.e., the annual payment that results in an equivalent NPV to the actual stream of O&M costs) and as NPVs using a statewide average real discount rate of 5.23%.

## 5.9   Interactive Effects

The TRM presents engineering equations for most measures.  This approach is desirable because it conveys information clearly and transparently, and is widely accepted in the industry.  Unlike simulation model results, engineering equations also provide flexibility and the opportunity for users to substitute local, specific information for specific input values.  Furthermore, the parameters can be changed in TRM updates to be applied in future years as better information becomes available.

One limitation is that some interactive effects between measures are not automatically captured.  Because we cannot know what measures will be implemented at the same time with the same customer, we cannot always capture the interactions between multiple measures within individual measure characterizations.  However, interactive effects with different end-uses are included in individual measure characterizations whenever possible.[33]  For instance, waste heat factors are included in the lighting characterizations to capture the interaction between more-efficient lighting measures and the amount of heating and/or cooling that is subsequently needed in the building.

By contrast, no effort is made to account for interactive effects between an efficient air conditioning measure and an efficient lighting measure, because it is impossible to know the specifics of the other measure in advance of its installation.  For custom measures and projects where a bundle of measures is being implemented at the same time, these kinds of interactive effects should be estimated.

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[33] For more information, please refer to the document, 'Dealing with interactive Effects During Measure Characterization" Memo to the Stakeholder Advisory Group dated 12/9/11.

# 6  Commercial and Industrial Measures

## 6.1  Agricultural End Use

### 6.1.1  Engine Block Timer for Agricultural Equipment

**DESCRIPTION**

The measure is a plug-in timer that is activated below a specific outdoor temperature to control an engine block heater in agricultural equipment. Engine block heaters are typically used during cold weather to pre-warm an engine prior to start, for convenience heaters are typically plugged in considerably longer than necessary to improve startup performance. A timer allows a user to preset the heater to come on for only the amount of time necessary to pre-warm the engine block, reducing unnecessary run time even if the baseline equipment has an engine block temperature sensor.

This measure was developed to be applicable to the following program types: RF.  If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

The efficient measure is an engine block heater operated by an outdoor plug-in timer (15 amp or greater) that turns on the heater only when the outdoor temperature is below 25 F.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline scenario is an engine block heater that is manually plugged in by the farmer to facilitate equipment startup at a later time.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life if assumed to be 3 years[34]

**DEEMED MEASURE COST**

The incremental cost per installed plug-in timer is $10.19[35].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**COINCIDENCE FACTOR**

Engine block timers only operate in the winter so the summer peak demand savings is zero.

---

[34]Equipment life is expected to be longer, but measure life is more conservative to account for possible attrition in use over time.

[35]Based on bulk pricing reported by EnSave, which administers the rebate in Vermont

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$\Delta kWh$ = ISR * Use Season * %Days * HrSave/Day * $kW_{heater}$ - ParaLd

= 78.39% * 87 days * 84.23% * 7.765 Hr/Day * 1.5 kW - 5.46 kWh

= 664 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESDH-V01-060112**

---

## 6.1.2    High Volume Low Speed Fans

### DESCRIPTION

The measure applies to 20-24 foot diameter horizontally mounted ceiling high volume low speed (HVLS) fans that are replacing multiple non HVLS fans that have reached the end of useful life in agricultural applications.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be classified as HVLS and have a VFD[36].

### DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be multiple non HVLS existing fans that have reached the end of s useful life.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[37].

### DEEMED MEASURE COST

The incremental capital cost for the fans are as follows[38]:.

| Fan Diameter Size (feet) | Incremental Cost |
|---|---|
| 20 | $4150 |
| 22 | $4180 |
| 24 | $4225 |

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C34 - Industrial Motor

### COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied.

---

[36] Act on Energy Commercial Technical Reference Manual No. 2010-4
[37] Ibid.
[38] Ibid.

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS** [39]

The annual electric savings from this measure are deemed values depending on fan size and apply to all building types:

| Fan Diameter Size (feet) | kWh Savings |
|---|---|
| 20 | 6576.85 |
| 22 | 8543.34 |
| 24 | 10018.22 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS** [40]

The annual kW savings from this measure are deemed values depending on fan size and apply to all building types:

| Fan Diameter Size (feet) | kW Savings |
|---|---|
| 20 | 2.408 |
| 22 | 3.128 |
| 24 | 3.668 |

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE:** CI-AGE-HVSF-V01-060112

---

[39] Ibid.
[40] Ibid.

## 6.1.3    High Speed Fans

**DESCRIPTION**

The measure applies to high speed exhaust, ventilation and circulation fans that are replacing an existing unit that reached the end of its useful life in agricultural applications.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

In order for this characterization to apply, the efficient equipment is assumed to be diffuser equipped and meet the following criteria[41].

| Diameter of Fan (inches) | Minimum Efficiency for Exhasut & Ventilation Fans | Minimum Efficiency for Circulation Fans |
|---|---|---|
| 24 through 35 | 14.0 cfm/W at 0.10 static pressure | 12.5 lbf/kW |
| 36 through 47 | 17.1 cfm/W at 0.10 static pressure | 18.2 lbf/kW |
| 48 through 71 | 20.3 cfm/W at 0.10 static pressure | 23.0 lbf/kW |

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline condition is assumed to be an existing fan that reached the end of its useful life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 7 years[42].

**DEEMED MEASURE COST**

The incremental capital cost for all fan sizes is $150[43].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C34 - Industrial Motor

**COINCIDENCE FACTOR**

The measure has deemed kW savings therefor a coincidence factor is not applied.

---

[41] Act on Energy Commercial Technical Reference Manual No. 2010-4
[42] Ibid.
[43] Ibid.

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS** [44]

The annual electric savings from this measure are deemed values depending on fan size and apply to all building types:

| Diameter of Fan (inches) | kWh |
|---|---|
| 24 through 35 | 372.14 |
| 36 through 47 | 625.23 |
| 48 through 71 | 1122.36 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS** [45]

The annual kW savings from this measure are deemed values depending on fan size and apply to all building types:

| Diameter of Fan (inches) | kW |
|---|---|
| 24 through 35 | 0.118 |
| 36 through 47 | 0.198 |
| 48 through 71 | 0.356 |

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE:** CI-AGE-HSF_-V01-060112

---

[44] Ibid.
[45] Ibid.

## 6.1.4   Live Stock Waterer

### DESCRIPTION

This measure applies to the replacement of electric open waterers with sinking or floating water heaters with equivalent herd size watering capacity of the old unit.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to an electrically heated thermally insulated waterer with minimum 2 inches of insulation. A thermostat is required on unit with heating element greater than or equal to 250 watts[46].

### DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be an electric open waterer with sinking or floating water heaters that have reached the end of useful life.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[47].

### DEEMED MEASURE COST

The incremental capital cost for the waters are $787.50:[48].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C04 - Non-Residential Electric Heating

### COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied

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[46] Act on Energy Commercial Technical Reference Manual No. 2010-4
[47] Ibid.
[48] Ibid.

---

**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS [49]

The annual electric savings from this measure is a deemed value and assumed to be 1592.85 kWh.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The annual kW savings from this measure is a deemed value and assumed to be 0.525 kW. [50]

**NATURAL GAS ENERGY SAVINGS**

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-AGE-LSW1-V01-060112

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[49] Ibid.
[50] Ibid.

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## 6.2 Food Service Equipment End Use

### 6.2.1 Combination Oven

**DESCRIPTION**

This measure applies to natural gas fired high efficiency combination convection and steam ovens installed in a commercial kitchen replacing existing equipment at the end of its useful life.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be a new natural gas combination convection with steam oven cooking efficiency ≥ 38% and convection mode cooking efficiency ≥ 44% utilizing ASTM standard F2861 and meet idle requirements below[51]:

Idle Rate Requirements for Commercial Combination Ovens/Steamers

| Combi Oven Type | Steam Mode Idle Rate | Convection Mode Idle Rate |
|---|---|---|
| Gas Combi < 15 pan capacity | ≤ 15,000 Btu/h | ≤ 9,000 Btu/h |
| Gas Combi 15-28 pan capacity | ≤ 18,000 Btu/h | ≤ 11,000 Btu/h |
| Gas Combi > 28 pan capacity | ≤ 28,000 Btu/h | ≤ 17,000 Btu/ |

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is a new or existing natural gas combination convection and steam ovens that do not meet the efficient equipment criteria

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 12 years[52]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $4300[53]

**DEEMED O&M COST ADJUSTMENTS**

N/A

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[51] http://www.fishnick.com/saveenergy/rebates/combis.pdf
[52] Deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011.
[53] Ibid.

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

## Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 644 therms.[54]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-CBOV-V01-060112**

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[54] Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,   May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

## 6.2.2   Commercial Solid and Glass Door Refrigerators & Freezers

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 was developed to be applicable to the following program types: TOS and NC. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a new vertical solid or glass door refrigerator or freezer or vertical chest 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 an existing solid or glass door refrigerator or freezer meeting the minimum federal manufacturing standards as specified by the Energy Policy Act of 2005.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years [55].

---

[55]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

**DEEMED MEASURE COST**

The incremental capital cost for this measure is provided below[56].

| Type | Refrigerator incremental Cost, per unit | Freezer Incremental Cost, per unit |
|---|---|---|
| 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

**LOADSHAPE**

Loadshape C23 - Commercial Refrigeration

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be 0.937.[57]

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh  = (kWhbase – kWhee) * 365.25

Where:

kWhbase= baseline maximum daily energy consumption in kWh

= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown

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[56] 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 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.

[57] The CF for Commercial Refrigeration was calculated based upon the Ameren provided eShapes

in the table below.

| Type | kWhbase[58] |
|------|------------|
| 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 |

kWhee[59]        = 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 kWhee | Freezer kWhee |
|------|-------------------|---------------|
| 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

365.25   = days per year

For example a solid door refrigerator with a volume of 15 would save

ΔkWh     = (3.54 – 2.76) * 365.25

= 285 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW      = ΔkWh / HOURS * CF

---

[58]Energy Policy Act of 2005. Accessed on 7/7/10. <http://www.epa.gov/oust/fedlaws/publ_109-058.pdf>
[59]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>

Where:

HOURS = equipment is assumed to operate continuously, 24 hours per day, 365.25 days per year.
= 8766
CF = Summer Peak Coincidence Factor for measure
= 0.937

---

For example a solid door refrigerator with a volume of 15 would save

$\Delta$kW = 285/ 8766 * .937

=0.030 kW

---

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-CSDO-V01-060112**

## 6.2.3   Commercial Steam Cooker

**DESCRIPTION**

To qualify for this measure the installed equipment must be an ENERGY STAR® steamer in place of a standard steamer in a commercial kitchen.  Savings are presented dependent on the pan capacity and corresponding idle rate at heavy load cooking capacity and if the steamer is gas or electric.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be as follows:

| Gas | Electric |
|---|---|
| ENERGY STAR® qualified with 38% minimum cooking energy efficiency at heavy load (potato) cooking capacity for gas steam cookers. | ENERGY STAR® qualified with 50% minimum cooking energy efficiency at heavy load (potato) cooking capacity for electric steam cookers. |

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is assumed to be a non-ENERGY STAR® commercial steamer at end of life.  It is assumed that the efficient equipment and baseline equipment have the same number of pans.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 12 years[60]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $998[61] for a natural gas steam cooker or $2490[62] for an electric steam cooker.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C01 - Commercial Electric Cooking

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[60]California DEER 2008 which is also used by both the Food Service Technology Center and ENERGY STAR®.
[61]Source  for incremental cost for efficient natural gas steamer is RSG Commercial Gas Steamer Workpaper, January 2012.
[62]Source for efficient electric steamer incremental cost is $2,490 per 2009 PG&E Workpaper - PGECOFST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComeEd C & I TRM.

### COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[63]:

| Location | CF |
|---|---|
| Fast Food Limited Menu | 0.32 |
| Fast Food Expanded Menu | 0.41 |
| Pizza | 0.46 |
| Full Service Limited Menu | 0.51 |
| Full Service Expanded Menu | 0.36 |
| Cafeteria | 0.36 |

---

**Algorithm**

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### CALCULATION OF SAVINGS

Formulas below are applicable to both gas and electric steam cookers. Please use appropriate lookup values and identified flags.

### ENERGY SAVINGS

$\Delta$Savings = ($\Delta$Idle Energy + $\Delta$Preheat Energy + $\Delta$Cooking Energy) * Z

For a gas cooker: $\Delta$Savings = $\Delta$Btu * 1/100,000 *Z

For an electric steam cooker: $\Delta$Savings = $\Delta$kWh *Z

Where Z = days/yr steamer operating (use 365.25 days/yr if heavy use restaurant and exact number unknown)

Where:

$\Delta$Idle Energy = $((((1- CSM_{\%Baseline})* IDLE_{BASE} + CSM_{\%Baseline} * PC_{BASE} * E_{FOOD} / EFF_{BASE})*(HOURS_{day} - (F / PC_{Base}) - ( PRE_{number} *0.25))) - (((1- CSM_{\%ENERGYSTAR}) * IDLE_{ENERGYSTAR} + CSM_{\%ENERGYSTAR} * PC_{ENERGY} * E_{FOOD} / EFF_{ENERGYSTAR}) * (HOURS_{Day} - (F l/ PC_{ENERGY} ) - (PRE_{number} * 0.25 ))))$

---

---

Where:

$CSM_{\%Baseline}$      = Baseline Steamer Time in Manual Steam Mode (% of time)

          = 90%[64]

$IDLE_{Base}$      = Idle Energy Rate of Base Steamer[65]

| Number of Pans | $IDLE_{BASE}$ - Gas, Btu/hr | $IDLE_{BASE}$ - Electric, kw |
|---|---|---|
| 3 | 11,000 | 1.0 |
| 4 | 14,667 | 1.33 |
| 5 | 18,333 | 1.67 |
| 6 | 22,000 | 2.0 |

$PC_{Base}$      = Production Capacity of Base Steamer[66]

| Number of Pans | $PC_{BASE}$, gas (lbs/hr) | $PC_{BASE}$, electric (lbs/hr) |
|---|---|---|
| 3 | 65 | 70 |
| 4 | 87 | 93 |
| 5 | 108 | 117 |
| 6 | 130 | 140 |

$E_{FOOD}$=      Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food (Btu/lb or kW/lb)

          =105 Btu/lb[67] (gas steamers) or 0.0308[8] (electric steamers)

$EFF_{BASE}$      =Heavy Load Cooking Efficiency for Base Steamer

          =15%[68] (gas steamers) or 26%[9] (electric steamers)

---

[64]Food Service Technology Center 2011 Savings Calculator
[65]Food Service Technology Center 2011 Savings Calculator
[66]Production capacity per Food Service Technology Center 2011 Savings Calculator of 23.3333 lb/hr per pan for electric baseline steam cookers and 21.6667 lb/hr per pan for natural gas baseline steam cookers. ENERGY STAR® savings calculator uses 23.3 lb/hr per pan for both electric and natural gas baseline steamers.
[67]Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.
[68]Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.

HOURS$_{day}$ = Average Daily Operation (hours)

| Type of Food Service | Hoursday[69] |
|---|---|
| Fast Food, limited menu | 4 |
| Fast Food, expanded menu | 5 |
| Pizza | 8 |
| Full Service, limited menu | 8 |
| Cafeteria | 6 |
| Unknown | 1270 |
| Custom | Varies |

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[71]

CSM$_{\%ENERGYSTAR}$ = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)[72]

= 0%

IDLE$_{ENERGYSTAR}$ = Idle Energy Rate of ENERGY STAR®[73]

| Number of Pans | IDLE$_{ENERGY\ STAR}$ – gas, (Btu/hr) | IDLE$_{ENERGY\ STAR}$ – electric, (kW) |
|---|---|---|
| 3 | 6250 | 0.40 |
| 4 | 8333 | 0.53 |
| 5 | 10417 | 0.67 |
| 6 | 12500 | 0.80 |

---

[69]Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech
[70]ENERGY STAR® savings calculator which references Food Service Technology research on average use, 2009
[71]Reference amount used by both Food Service Technology Center and ENERGY STAR® savings calculator
[72]Reference information from the Food Service Technology Center siting that ENERGY STAR® steamers are not typically operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC for efficient steamer. Both baseline & efficient steamer mode values should be considered for users in Illinois market.
[73]Food Service Technology Center 2011 Savings Calculator

$PC_{ENERGY}$ = Production Capacity of ENERGY STAR® Steamer[74]

| Number of Pans | $PC_{ENERGY}$ - gas(lbs/hr) | $PC_{ENERGY}$ – electric (lbs/hr) |
|---|---|---|
| 3 | 55 | 50 |
| 4 | 73 | 67 |
| 5 | 92 | 83 |
| 6 | 110 | 100 |

$EFF_{ENERGYSTAR}$ = Heavy Load Cooking Efficiency for ENERGY STAR® Steamer(%)

=38%[75] (gas steamer) or 50%[15] (electric steamer)

$PRE_{number}$ = Number of preheats per day

=1[76] (if unknown, use 1)

Where:

ΔPreheat Energy = ( $PRE_{number}$ * Δ $Pre_{heat}$)

Where:

$PRE_{number}$ = Number of Preheats per Day

=1[77](if unknown, use 1)

$PRE_{heat}$ = Preheat energy savings per preheat

= 11,000 Btu/preheat[78] (gas steamer) or 0.5 kWh/preheat[79] (electric steamer)

---

[74]Production capacity per Food Service Technology Center 2011 Savings Calculator of 18.3333 lb/hr per pan for gas ENERGY STAR® steam cookers and 16.6667 lb/hr per pan for electric ENERGY STAR® steam cookers. ENERGY STAR® savings calculator uses 16.7 lb/hr per pan for electric and 20 lb/hr for natural gas ENERGY STAR® steamers.

[75]Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for Tier 1A and Tier 1B qualified electric and natural gas steamer heavy cooking load energy efficiencies and
http://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Steam_Cookers_Program_Requirements.pdf?7010-36eb

[76]Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

[77]Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

[78]Ohio TRM which references 2002 Food Service Technology Center "Commercial Cooking Appliance Technology Assessment" Chapter 8: Steamers. This is time also used by ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC. 11,000 Btu/preheat is from 72,000 Btu/hr * 15 min/hr /60 min/hr for gas steamers and 0.5 kWh/preheat is from 6 kW/preheat * 15 min/hr / 60 min/hr

[79] Reference Food Service Technology Center 2011 Savings Calculator values for Baseline Preheat Energy.

Where:

ΔCooking Energy = ((1/ EFFBASE) - (1/ EFFENERGY STAR®)) * F

Where:

| | |
|---|---|
| $EFF_{BASE}$ | =Heavy Load Cooking Efficiency for Base Steamer |
| | =15%[80] (gas steamer) or 26%[28] (electric steamer) |
| $EFF_{ENERGYSTAR}$ | =Heavy Load Cooking Efficiency for ENERGY STAR® Steamer |
| | =38%[81] (gas steamer) or 50%[23] (electric steamer) |
| F | = Food cooked per day (lbs/day) |
| | = custom or if unknown, use 100 lbs/day[82] |
| $E_{FOOD}$ Food[83] | = Amount of Energy Absorbed by the food during cooking known as ASTM Energy to |

| $E_{FOOD}$ - gas(Btu/lb) | $E_{FOOD}$ (kWh/lb) |
|---|---|
| 105[84] | 0.0308[85] |

---

[80] Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.
[81] Ibid.
[82]Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator
[83]Reference ENERGY STAR® savings calculator at
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.
[84]Ibid.
[85]Ibid.

**EXAMPLE**

For a gas steam cooker:  A 3 pan steamer in a restaurant

ΔSavings  = ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy  *Z * 1/100.000
ΔIdle Energy = ((((1- .9)* 11000  + .9 * 65 * 105 /.15 )*(12 - (100 / 65)-(1-.25)))) - (((1-0) * 6250 + 0  * 55 * 105  / 0.38) * (12 - (100 / 55) - (1-0.25)))) +
ΔPreheat Energy = (1  *11,000) +
ΔCooking Energy = (((1/ 0.15) - (1/ 0.38)) * (100 lb/day * 105 btu/lb)))
* 365.25 days)) *1/100,000 =
=1536 therms

For an electric steam cooker:  A 3 pan steamer in a restaurant

ΔSavings  = ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy  *Z
ΔIdle Energy = ((((1- .9)* 1.0 + .9 * 70 * 0.0308 /.26 )*(12 - (100 / 70)-(1*.25))) - (((1-0) * 0.4 + 0  * 50 * .0308   / 0.50) * (12 - (100 / 50) - (1*.25)))) +
ΔPreheat Energy = (1  *0.5)) +
ΔCooking Energy = (((1/ 0.26) - (1/ 0.5)) * (100 * 0.0308 )))
* 365.25 days=

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

This is only applicable to the electric steam cooker.

$$\Delta kW = (\Delta kWh/(HOURSDay * DaysYear)) * CF$$

Where:

CF        =Summer Peak Coincidence Factor for measure is provided below for different locations[86]:

| Location | CF |
|---|---|
| Fast Food Limited Menu | 0.32 |
| Fast Food Expanded Menu | 0.41 |
| Pizza | 0.46 |
| Full Service Limited Menu | 0.51 |
| Full Service Expanded Menu | 0.36 |
| Cafeteria | 0.36 |

Days$_{Year}$   =Annual Days of Operation

=custom or 365.25 days a year[87]

---

[86]Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls,
http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech

Other values as defined above

---

**EXAMPLE**

For 3 pan electric steam cooker located in a cafeteria:

$\Delta kW$ = $(\Delta kWh/(HOURS_{Day} *Days_{Year}))$ * CF =

(30,533/(12*365.25))*.36 =
  2.51 kW

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

This is applicable to both gas and electric steam cookers.

$\Delta Water = [(W_{BASE} - W_{ENERGYSTAR®)*}HOURS_{Day} *Days_{Year}$

Where

$W_{BASE}$ = Water Consumption Rate of Base Steamer (gal/hr)

= 40[88]

$W_{ENERGYSTAR}$ = Water Consumption Rate of ENERGY STAR® Steamer look up[89]

| CEE Tier | gal/hr |
|---|---|
| Tier 1A | 15 |
| Tier 1B | 4 |
| Avg Efficient | 10 |
| Avg Most Efficient | 3 |

$Days_{Year}$ =Annual Days of Operation

=custom or 365.25 days a year[90]

---

[88] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.
[89]Source Consortium for Energy Efficiency, Inc. September 2010 "Program Design Guidance for Steamers" for Tier 1A and Tier 1B water requirements.  Ohio Technical Reference Manual 2010 for 10 gal/hr water consumption which can be used when Tier level is not known.
[90]Source for 365.25 days/yr is ENERGY STAR® savings calculator which references Food Service Technology research on average use, 2009.

---

**EXAMPLE**

For example, an electric 3 pan steamer with average efficiency in a restaurant

       ΔWater  =
       ΔWater  = [(40 -10)*12*365.25
              = 131,490 gallons

**Deemed O&M Cost Adjustment Calculation**

N/A

**REFERENCE TABLES**

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-STMC-V01-060112**

## 6.2.4   Conveyor Oven

**DESCRIPTION**

This measure applies to natural gas fired high efficiency conveyor ovens installed in commercial kitchens replacing existing natural gas units with conveyor width greater than 25 inches.

Conveyor ovens are available using four different heating processes: infrared, natural convection with a ceramic baking hearth, forced convection or air impingement, or a combination of infrared and forced convection. Conveyor ovens are typically used for producing a limited number of products with similar cooking requirements at high production rates.  They are highly flexible and can be used to bake or roast a wide variety of products including pizza, casseroles, meats, breads, and pastries.

Some manufacturers offer an air-curtain feature at either end of the cooking chamber that helps to keep the heated air inside the conveyor oven.  The air curtain operates as a virtual oven wall and helps reduce both the idle energy of the oven and the resultant heat gain to the kitchen.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be a natural gas conveyor oven with a tested baking energy efficiency > 42% and an idle energy consumption rate < 57,000 Btu/h utilizing ASTM standard F1817.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is an existing pizza deck oven at end of life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 17 years.[91]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $1800[92].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

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[91]Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,   May 27, 2011
[92] Ibid.

**COINCIDENCE FACTOR**

N/A

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 733 Therms[93].

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-CVOV-V01-060112**

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[93]Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,   May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary

## 6.2.5 ENERGY STAR Convection Oven

### DESCRIPTION

This measure applies to natural gas fired ENERGY STAR convection ovens installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas convection oven with a cooking efficiency ≥ 44% utilizing ASTM standard 1496 and an idle energy consumption rate < 13,000 Btu/h

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a natural gas convection oven that is not ENERGY STAR certified and is at end of life.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[94]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $50[95]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

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[94] Lifetime from ENERGY STAR commercial griddle which cites reference as "FSTC research on available models, 2009" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG
[95] Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

Custom calculation below, otherwise use deemed value of 306 therms. [96]

$\Delta$Therms = ($\Delta$DailyIdle Energy + $\Delta$DailyPreheat Energy + $\Delta$DailyCooking Energy) * Days /100000

Where:

$\Delta$DailyIdleEnergy = (IdleBase* IdleBaseTime)- (IdleENERGYSTAR * IdleENERGYSTARTime)

$\Delta$DailyPreheatEnergy = (PreHeatNumberBase * PreheatTimeBase / 60 * PreheatRateBase) – (PreheatNumberENERGYSTAR* PreheatTimeENERGYSTAR/60 * PreheatRateENERGYSTAR)

$\Delta$DailyCookingEnergy = (LB * EFOOD/ EffBase) - (LB * EFOOD/ EffENERGYSTAR)

Where:

| | |
|---|---|
| HOURSday | = Average Daily Operation |
| | = custom or if unknown, use 12 hours |
| Days | = Annual days of operation |
| | = custom or if unknown, use 365.25 days a year |
| LB | = Food cooked per day |
| | = custom or if unknown, use 100 pounds |
| EffENERGYSTAR | = Cooking Efficiency ENERGY STAR |
| | = custom or if unknown, use 44% |
| EffBase | = Cooking Efficiency Baseline |

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[96] Algorithms and assumptions derived from ENERGY STAR Oven Commercial Kitchen Equipment Savings Calculator.http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

---

= custom or if unknown, use 30%

PCENERGYSTAR = Production Capacity ENERGY STAR

= custom or if unknown, use 80 pounds/hr

PCBase = Production Capacity base

= custom or if unknown, use 70 pounds/hr

PreheatNumberENERGYSTAR = Number of preheats per day

= custom or if unknown, use 1

PreheatNumberBase = Number of preheats per day

= custom or if unknown, use 1

PreheatTimeENERGYSTAR = preheat length

= custom or if unknown, use 15 minutes

PreheatTimeBase = preheat length

= custom or if unknown, use 15 minutes

PreheatRateENERGYSTAR = preheat energy rate high efficiency

= custom or if unknown, use 44000 btu/h

PreheatRateBase = preheat energy rate baseline

= custom or if unknown, use 76000 btu/h

IdleENERGYSTAR = Idle energy rate

= custom or if unknown, use 13000 btu/h

IdleBase = Idle energy rate

= custom or if unknown, use 18000 btu/h

IdleENERGYSTARTime = ENERGY STAR Idle Time

=HOURsday-LB/PCENERGYSTAR –PreHeatTimeENERGYSTAR/60

=12 – 100/80 – 15/60

=10.5 hours

IdleBaseTime = BASE Idle Time

= HOURsday-LB/PCbase –PreHeatTimeBase/60

=Custom or if unknown, use

=12 – 100/70-15/60

=10.3 hours

EFOOD = ASTM energy to food

= 250 btu/pound

---

**EXAMPLE**

For example, an ENERGY STAR Oven with a cooking energy efficiency of 44% and default values from above would save.

ΔTherms = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Days /100000

Where:

| | |
|---|---|
| ΔDailyIdleEnergy | =(18000*10.3)- (13000*10.5) |
| | = 49286 btu |
| ΔDailyPreheatEnergy | = (1 * 15 / 60 *76000) – (1 * 15 / 60 *44000) |
| | = 8000 btu |
| ΔDailyCookingEnergy | = (100 * 250/ .30) - (100 * 250/ .44) |
| | =26515 btu |
| ΔTherms | = (49286+8000+26515)* 365.25 /100000 |
| | =306 therms |

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-ESCV-V01-060112**

## 6.2.6   ENERGY STAR Dishwasher

### DESCRIPTION

This measure applies to ENERGY STAR high and low temp undercounter single tank door type, single tank conveyor, and multiple tank conveyor dishwashers installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR certified dishwasher meeting idle energy rate (kW) and water consumption (gallons/rack) limits, as determined by both machine type and sanitation approach (chemical/low temp versus high temp).

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a dishwasher that's not ENERGY STAR certified and at end of life.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be[97]

| Dishwasher type | | Equipment Life |
|---|---|---|
| Low Temp | Under Counter | 10 |
| | Door Type | 15 |
| | Single Tank Conventional | 20 |
| | Multi Tank Conventional | 20 |
| High Temp | Under Counter | 10 |
| | Door Type | 15 |
| | Single Tank Conventional | 20 |
| | Multi Tank Conventional | 20 |

---

[97] Lifetime from ENERGY STAR HFHC which cites reference as "FSTC research on available models, 2009" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

**DEEMED MEASURE COST**

The incremental capital cost for this measure is[98]

| | Dishwasher type | Incremental Cost |
|---|---|---|
| **Low Temp** | Under Counter | $530 |
| | Door Type | $530 |
| | Single Tank Conventional | $170 |
| | Multi Tank Conventional | $0 |
| **High Temp** | Under Counter | $1000 |
| | Door Type | $500 |
| | Single Tank Conventional | $270 |
| | Multi Tank Conventional | $0 |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C01 - Commercial Electric Cooking

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

Summer Peak Coincidence Factor for measure is provided below for different restaurant types[99]:

| Location | CF |
|---|---|
| Fast Food Limited Menu | 0.32 |
| Fast Food Expanded Menu | 0.41 |
| Pizza | 0.46 |
| Full Service Limited Menu | 0.51 |
| Full Service Expanded Menu | 0.36 |
| Cafeteria | 0.36 |

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**Algorithm**

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**ENERGY SAVINGS**

ENERGY STAR dishwashers save energy in three categories, building water heating, booster water heating and idle energy. Building water heating and booster water heating could be either electric or natural gas. These deemed

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[98] Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG
[99] Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech

values are presented in a table format. Savings all water heating combinations are found in the tables below. [100]

Electric building and booster water heating

| | Dishwasher type | kWh | Therms |
|---|---|---|---|
| **Low Temp** | Under Counter | 1,213 | 0 |
| | Door Type | 12,135 | 0 |
| | Single Tank Conventional | 11,384 | 0 |
| | Multi Tank Conventional | 17,465 | 0 |
| **High Temp** | Under Counter | 7471 | 0 |
| | Door Type | 14143 | 0 |
| | Single Tank Conventional | 19235 | 0 |
| | Multi Tank Conventional | 34153 | 0 |

Electric building and natural gas booster water heating

| | Dishwasher type | kWh | Therms |
|---|---|---|---|
| **Low Temp** | Under Counter | 9089 | 0 |
| | Door Type | 21833 | 0 |
| | Single Tank Conventional | 24470 | 0 |
| | Multi Tank Conventional | 29718 | 0 |
| **High Temp** | Under Counter | 7208 | 110 |
| | Door Type | 19436 | 205 |
| | Single Tank Conventional | 29792 | 258 |
| | Multi Tank Conventional | 34974 | 503 |

Natural Gas building and electric booster water heating

| | Dishwasher type | kWh | Therms |
|---|---|---|---|
| **Low Temp** | Under Counter | 0 | 56 |
| | Door Type | 0 | 562 |
| | Single Tank Conventional | 0 | 527 |
| | Multi Tank Conventional | 0 | 809 |
| **High Temp** | Under Counter | 2717 | 220 |
| | Door Type | 5269 | 441 |
| | Single Tank Conventional | 8110 | 515 |
| | Multi Tank Conventional | 12419 | 1007 |

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[100]Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator.http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

Natural Gas building and booster water heating

| Dishwasher type | | kWh | Therms |
|---|---|---|---|
| Low Temp | Under Counter | 0 | 56 |
| | Door Type | 0 | 562 |
| | Single Tank Conventional | 0 | 527 |
| | Multi Tank Conventional | 0 | 809 |
| High Temp | Under Counter | 0 | 330 |
| | Door Type | 198 | 617 |
| | Single Tank Conventional | 1752 | 773 |
| | Multi Tank Conventional | 0 | 1510 |

**WATER SAVINGS**

Using standard assumptions water savings would be:

| Dishwasher type | | Savings (gallons) |
|---|---|---|
| Low Temp | Under Counter | 6,844 |
| | Door Type | 6,8474 |
| | Single Tank Conventional | 64,240 |
| | Multi Tank Conventional | 98,550 |
| High Temp | Under Counter | 26,828 |
| | Door Type | 50,078 |
| | Single Tank Conventional | 62,780 |
| | Multi Tank Conventional | 122,640 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = ΔkWh/ AnnualHours

Where:

AnnualHours = Hours * Days

= 365.25 * 18

= 6575 annual hours

Example:

A low temperature undercounter dishwasher with electric building and booster water heaters would save:

ΔkW = ΔkWh/ AnnualHours

= 1213/6575

= 0.184 kW

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-ESDW-V01-060112**

## 6.2.7    ENERGY STAR Fryer

**DESCRIPTION**

This measure applies to natural gas fired ENERGY STAR fryer installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be a natural gas fryer with a heavy load cooking efficiency ≥ 50% utilizing ASTM standard F1361 or F2144.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is a natural gas fryer that is not ENERGY STAR certified at end of life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 15 years.[101]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $1200.[102]

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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[101]Lifetime from ENERGY STAR commercial griddle which cites reference as "FSTC research on available models, 2009" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG
[102]Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

| Algorithm |
|---|

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS[103]**

Custom calculation below, otherwise use deemed value of 505 Therms.

ΔTherms = (ΔDailyIdle Energy + ΔDailyPreheat Energy + ΔDailyCooking Energy) * Days /100000

Where:

ΔDailyIdleEnergy =(IdleBase* IdleBaseTime) – (IdleENERGYSTAR * IdleENERGYSTARTime)

ΔDailyPreheatEnergy = (PreHeatNumberBase * PreheatTimeBase / 60 * PreheatRateBase) – (PreheatNumberENERGYSTAR* PreheatTimeENERGYSTAR/60 * PreheatRateENERGYSTAR)

ΔDailyCookingEnergy = (LB * EFOOD/ EffBase) - (LB * EFOOD/ EffENERGYSTAR)

Where:

HOURSday = Average Daily Operation

= custom or if unknown, use 16 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

LB = Food cooked per day

= custom or if unknown, use 150 pounds

EffENERGYSTAR = Cooking Efficiency ENERGY STAR

= custom or if unknown, use 50%

EffBase = Cooking Efficiency Baseline

---

[103] Algorithms and assumptions derived from ENERGY STAR fryer Commercial Kitchen Equipment Savings Calculator.http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

|                         | = custom or if unknown, use 35% |
|-------------------------|---------------------------------|
| PCENERGYSTAR            | = Production Capacity ENERGY STAR |
|                         | = custom or if unknown, use 65 pounds/hr |
| PCBase                  | = Production Capacity base |
|                         | = custom or if unknown, use 60 pounds/hr |
| PreheatNumberENERGYSTAR | = Number of preheats per day |
|                         | = custom or if unknown, use 1 |
| PreheatNumberBase       | = Number of preheats per day |
|                         | = custom or if unknown, use 1 |
| PreheatTimeENERGYSTAR   | = preheat length |
|                         | = custom or if unknown, use 15 minutes |
| PreheatTimeBase         | = preheat length |
|                         | = custom or if unknown, use 15 minutes |
| PreheatRateENERGYSTAR   | = preheat energy rate high efficiency |
|                         | = custom or if unknown, use 62000 btu/h |
| PreheatRateBase         | = preheat energy rate baseline |
|                         | = custom or if unknown, use 64000 btu/h |
| IdleENERGYSTAR          | = Idle energy rate |
|                         | = custom or if unknown, use 9000 btu/h |
| IdleBase                | = Idle energy rate |
|                         | = custom or if unknown, use 14000 btu/h |
| IdleENERGYSTARTime      | = ENERGY STAR Idle Time |
|                         | = HOURsday-LB/PCENERGYSTAR −PreHeatTimeENERGYSTAR/60 |
|                         | =Custom or if unknown, use |
|                         | =16 − 150/65-15/60 |
|                         | =13.44 hours |
| IdleBaseTime            | = BASE Idle Time |

= HOURsday-LB/PCbase –PreHeatTimeBase/60

=Custom or if unknown, use

=16 – 150/60-15/60

=13.25 hours

EFOOD = ASTM energy to food

= 570 btu/pound

---

**EXAMPLE**

For example, an ENERGY STAR fryer with a tested heavy load cooking energy efficiency of 50% and an idle energy rate of 120,981 btu and an Idle Energy Consumption Rate 9000 btu would save.

ΔTherms = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Days /100000

Where:

| | |
|---|---|
| ΔDailyIdleEnergy | =(18550*13.25)- (120981 * 13.44) |
| | = 64519 btu |
| ΔDailyPreheatEnergy | = (1 * 15 / 60 *64000) – (1 * 15 / 60 *62000) |
| | = 500 btu |
| ΔDailyCookingEnergy | = (150 * 570/ .35) - (150 * 570/ .5) |
| | =73286 btu |
| ΔTherms | = (64519+500+73286)* 365.25 /100000 |
| | =508 therms |

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-ESFR-V01-060112**

## 6.2.8   ENERGY STAR Griddle

**DESCRIPTION**

This measure applies to electric and natural gas fired high efficiency griddle installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be an ENERGY STAR natural gas  or electric griddle with a tested heavy load cooking energy efficiency of 70 percent (electric) 38 percent (gas) or greater and an idle energy rate of 2,650 Btu/h per square foot of cooking surface or less, utilizing ASTM F1275. The griddle must have an Idle Energy Consumption Rate < 2,600 Btu/h per square foot of cooking surface.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is an existing natural gas or electric griddle that's not ENERGY STAR certified and is at end of use.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 12 years[104]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $0 for and electric griddle and $60 for a gas griddle.[105]

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C01 - Commercial Electric Cooking

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[104] Lifetime from ENERGY STAR commercial griddle which cites reference as "FSTC research on available models, 2009" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG
[105] Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[106]:

| Location | CF |
|---|---|
| Fast Food Limited Menu | 0.32 |
| Fast Food Expanded Menu | 0.41 |
| Pizza | 0.46 |
| Full Service Limited Menu | 0.51 |
| Full Service Expanded Menu | 0.36 |
| Cafeteria | 0.36 |

**Algorithm**

CALCULATION OF SAVINGS [107]

ELECTRIC ENERGY SAVINGS

$\Delta$kWh = ($\Delta$Idle Energy + $\Delta$Preheat Energy + $\Delta$Cooking Energy) * Days /1000

Where:

$\Delta$DailyIdleEnergy =[ IdleBase * Width * Length (LB/ PCBase) − (PreheatNumberBase* PreheatTimeBase/60)]- IdleENERGYSTAR * Width * Length (LB/ PCENERGYSTAR) − (PreheatNumberENERGYSTAR* PreheatTimeENERGYSTAR/60]

$\Delta$DailyPreheatEnergy = (PreHeatNumberBase * PreheatTimeBase / 60 * PreheatRateBase * Width * Depth) − (PreheatNumberENERGYSTAR* PreheatTimeENERGYSTAR/60 * PreheatRateENERGYSTAR * Width * Depth)

$\Delta$DailyCookingEnergy = (LB * EFOOD/ EffBase) - (LB * EFOOD/ EffENERGYSTAR)

Where:

HOURSday = Average Daily Operation

= custom or if unknown, use 12 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

LB = Food cooked per day

---

[106]Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech
[107] Algorithms and assumptions derived from ENERGY STAR Griddle Commercial Kitchen Equipment Savings Calculator.http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

= custom or if unknown, use 100 pounds

Width              = Griddle Width

= custom or if unknown, use 3 feet

Depth              = Griddle Depth

= custom or if unknown, use 2 feet

EffENERGYSTAR      = Cooking Efficiency ENERGY STAR

= custom or if unknown, use 70%

EffBase            = Cooking Efficiency Baseline

= custom or if unknown, use 65%

PCENERGYSTAR       = Production Capacity ENERGY STAR

= custom or if unknown, use 6.67 pounds/hr/sq ft

PCBase             = Production Capacity base

= custom or if unknown, use 5.83 pounds/hr/sq ft

PreheatNumberENERGYSTAR      = Number of preheats per day

= custom or if unknown, use 1

PreheatNumberBase     = Number of preheats per day

= custom or if unknown, use 1

PreheatTimeENERGYSTAR = preheat length

= custom or if unknown, use 15 minutes

PreheatTimeBase       = preheat length

= custom or if unknown, use 15 minutes

PreheatRateENERGYSTAR = preheat energy rate high efficiency

= custom or if unknown, use 1333 W/sq ft

PreheatRateBase       = preheat energy rate baseline

= custom or if unknown, use 2667 W/sq ft

IdleENERGYSTAR      = Idle energy rate

= custom or if unknown, use 320 W/sq ft

IdleBase = Idle energy rate

= custom or if unknown, use 400 W/sq ft

EFOOD = ASTM energy to food

= 139 w/pound

For example, an ENERGY STAR griddle with a tested heavy load cooking energy efficiency of 70 percent or greater and an idle energy rate of 320 W per square foot of cooking surface or less would save.

ΔDailyIdleEnergy =[ 400* 3 * 2 (100/5.83) – (1* 15/60)]- [320* 3 * 2 (100/6.67) – (1* 15/60]

= 3583 W

ΔDailyPreheatEnergy = (1* 15 / 60 * 2667 * 3 * 2) – (1* 15/60 * 1333 * 3 * 2)

=2000 W

ΔDailyCookingEnergy = (100 * 139/ .65) -  (100 * 139/ .70)

=1527 W

ΔkWh = (2000+1527+3583) * 365.25 /1000

=2597 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

kW = ΔkWh/Hours * CF

For example, an ENERGY STAR griddle in a cafeteria with a tested heavy load cooking energy efficiency of 70 percent or greater and an idle energy rate of 320 W per square foot of cooking surface or less would save

=2595 kWh/4308 * .36

= 0.22 kW

**NATURAL GAS ENERGY SAVINGS**

Custom calculation below, otherwise use deemed value of 149 therms.

ΔTherms = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Days /100000

Where:

ΔDailyIdleEnergy =[ IdleBase * Width * Length (LB/ PCBase) – (PreheatNumberBase* PreheatTimeBase/60)]- IdleENERGYSTAR * Width * Length (LB/ PCENERGYSTAR) – (PreheatNumberENERGYSTAR* PreheatTimeENERGYSTAR/60]

$$\Delta DailyPreheatEnergy = (PreHeatNumberBase * PreheatTimeBase / 60 * PreheatRateBase * Width * Depth) - (PreheatNumberENERGYSTAR * PreheatTimeENERGYSTAR/60 * PreheatRateENERGYSTAR * Width * Depth)$$

$$\Delta DailyCookingEnergy = (LB * EFOOD/ EffBase) - (LB * EFOOD/ EffENERGYSTAR)$$

Where (new variables only):

| | |
|---|---|
| EffENERGYSTAR | = Cooking Efficiency ENERGY STAR |
| | = custom or if unknown, use 38% |
| EffBase | = Cooking Efficiency Baseline |
| | = custom or if unknown, use 32% |
| PCENERGYSTAR | = Production Capacity ENERGY STAR |
| | = custom or if unknown, use 7.5 pounds/hr/sq ft |
| PCBase | = Production Capacity base |
| | = custom or if unknown, use 4.17 pounds/hr/sq ft |
| PreheatRateENERGYSTAR | = preheat energy rate high efficiency |
| | = custom or if unknown, use 10000 btu/h/sq ft |
| PreheatRateBase | = preheat energy rate baseline |
| | = custom or if unknown, use 14000 btu/h/sq ft |
| IdleENERGYSTAR | = Idle energy rate |
| | = custom or if unknown, use 2650 btu/h/sq ft |
| IdleBase | = Idle energy rate |
| | = custom or if unknown, use 3500 btu/h/sq ft |
| EFOOD | = ASTM energy to food |
| | = 475 btu/pound |

For example, an ENERGY STAR griddle with a tested heavy load cooking energy efficiency of 38 percent or greater and an idle energy rate of 2,650 Btu/h per square foot of cooking surface or less and an Idle Energy Consumption Rate < 2,600 Btu/h per square foot of cooking surface would save.

ΔDailyIdleEnergy = [ 3500* 3 * 2 (100/4.17) – (1* 15/60)]- 2650* 3 * 2 (100/7.5) – (1* 15/60]

= 11258 Btu

ΔDailyPreheatEnergy = (1* 15 / 60 * 14,000 * 3 * 2) – (1* 15/60 * 10000 * 3 * 2)

=6000 btu

ΔDailyCookingEnergy = (100 * 475/ .32) - (100 * 475/ .38)

=23438 btu

ΔTherms = (11258 + 6000 + 23438) * 365.25 /100000

=149 therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-ESGR-V01-060112**

## 6.2.9   ENERGY STAR Hot Food Holding Cabinets

### DESCRIPTION

This measure applies to electric ENERGY STAR hot food holding cabinets (HFHC) installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR certified HFHC.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an electric HFHC that's not ENERGY STAR certified and at end of life.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[108]

### DEEMED MEASURE COST

The incremental capital cost for this measure is[109]

| HFHC Size | Incremental Cost |
|---|---|
| Full Size (20 cubic feet) | $1200 |
| ¾ Size (12 cubic feet) | $1800 |
| ½ Size (8 cubic feet) | $1500 |

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

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108 Lifetime from ENERGY STAR HFHC which cites reference as "FSTC research on available models, 2009"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG
109 Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[110]:

| Location | CF |
|---|---|
| Fast Food Limited Menu | 0.32 |
| Fast Food Expanded Menu | 0.41 |
| Pizza | 0.46 |
| Full Service Limited Menu | 0.51 |
| Full Service Expanded Menu | 0.36 |
| Cafeteria | 0.36 |

## Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Custom calculation below, otherwise use deemed values depending on HFHC size[111]

| Cabinet Size | Savings (kWh) |
|---|---|
| Full Size HFHC | 9308 |
| ¾ Size HFHC | 3942 |
| ½ Size HFHC | 2628 |

ΔkWh = HFHCBaselinekWh - HFHCENERGYSTARkWh

Where:

   HFHCBaselinekWh = PowerBaseline* HOURSday * Days/1000

   PowerBaseline     = Custom, otherwise

| Cabinet Size | Power (W) |
|---|---|
| Full Size HFHC | 2500 |
| ¾ Size HFHC | 1200 |
| ½ Size HFHC | 800 |

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[110]Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls,
http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech
[111] Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator.http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

HOURSday = Average Daily Operation

= custom or if unknown, use 15 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

HFHCENERGYSTARkWh = PowerENERGYSTAR* HOURSday * Days/1000

PowerENERGYSTAR = Custom, otherwise

| Cabinet Size | Power (W) |
|---|---|
| Full Size HFHC | 800 |
| ¾ Size HFHC | 480 |
| ½ Size HFHC | 320 |

HOURSday = Average Daily Operation

= custom or if unknown, use 15 hours

Days = Annual days of operation

= custom or if unknown, use 365.25 days a year

For example, if a full size HFHC is installed the measure would save:

ΔkWh = (PowerBaseline* HOURSday * Days)/1000 – (PowerENERGYSTAR* HOURSday * Days)/1000

= (2500*15*365.25)/1000 – (800*15*365.25)/1000

= 9,314 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = ΔkWh/Hours * CF

Where: Hours = Hoursday *Days

For example, if a full size HFHC is installed in a cafeteria the measure would save:

= 9,314 kWh / (15*365.25)* .36

=0 .61 kW

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-ESHH-V01-060112**

## 6.2.10  ENERGY STAR Ice Maker

### 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 excludes flake and nugget type ice machines. 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.

This measure was developed to be applicable to the following program types: TOS and NC.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a new 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 LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[112].

### DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.[113]

| 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 |
| 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

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[112]DEER 2008

[113]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>.

**LOADSHAPE**

Loadshape C23 - Commercial Refrigeration

**COINCIDENCE FACTOR**

The Summer Peak Coincidence Factor is assumed to equal 0.937

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWH = [(kWh_{base} - kWh_{ee}) / 100] * (DC * H) * 365.25$$

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.

| Ice Machine Type | kWhbase[114] | kWhee[115] |
|---|---|---|
| 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 kWhbase and kWhee into maximum kWh consumption per pound

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[114]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>.
[115]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>

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of ice.

DC = Duty Cycle of the ice machine

= 0.57[116]

H = Harvest Rate (pounds of ice made per day)

= Actual installed

365.35 = days per year

---

For example an ice machine with an ice making head producing 450 pounds of ice would save

ΔkWH = [(6.4 – 5.8) / 100] * (0..57 * 450) * 365.25

= 562 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = ΔkWh / (HOURS * DC) * CF

Where:

HOURS = annual operating hours

= 8766[117]

CF = 0.937

---

For example an ice machine with an ice making head producing 450 pounds of ice would save

ΔkW = 562/(8766*..57) * .937

= 0.105 kW

---

[116]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 and Energy 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). The value of 57% was utilized since it appears to represent a high quality data source.

[117]Unit is assumed to be connected to power 24 hours per day, 365.25 days per year.

**NATURAL GAS ENERGY SAVINGS**

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[118] 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

**MEASURE CODE: CI-FSE-ESIM-V01-060112**

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[118]AHRI Certification Directory, Accessed on 7/7/10.
<http://www.ahridirectory.org/ahridirectory/pages/home.aspx>

## 6.2.11  High Efficiency Pre-Rinse Spray Valve

DESCRIPTION

Pre-rise valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher.  More efficient spray valves use less water thereby reducing water consumption, water heating cost, and waste water (sewer) charges.  Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper.  The primary impacts of this measure are water savings.  Reduced hot water consumption saves either natural gas or electricity, depending on the type of energy the hot water heater uses.

This measure was developed to be applicable to the following program types: TOS, RF, and DI.  If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure, the new or replacement pre-rinse spray nozzle must use less than 1.6 gallons per minute with a cleanability performance of 26 seconds per plate or less.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment will vary based on the delivery method and is defined below:

| Time of Sale | Retrofit, Direct Install |
|---|---|
| The baseline equipment is assumed to be 1.6 gallons per minute.  The Energy Policy Act (EPAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03.  This performance standard went into effect January 1, 2006[119]. | The baseline equipment is assumed to be an existing pre-rinse spray valve with a flow rate of 1.9 gallons per minute.[120]  If existing pre-rinse spray valve flow rate is unknown, then existing pre-rinse spray valve must have been installed prior to 2006.   The Energy Policy Act (EPAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03.  This performance standard went into effect January 1, 2006 however, field data shows that not all nozzles in use have been replaced with the newer flow rate nozzle.  Products predating this standard can use up to five gallons per minute |

[120] Verification measurements taken at 195 installations showed average pre and post flowrates of 2.23 and 1.12 gallon per minute, respectively." from  IMPACT AND PROCESS EVALUATION FINAL REPORT for CALIFORNIA URBAN WATER CONSERVATION COUNCIL 2004-5 PRE-RINSE SPRAY VALVE INSTALLATION PROGRAM (PHASE 2) (PG&E Program # 1198-04; SoCalGas Program 1200-04) ("CUWCC Report", Feb 2007)

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 5 years[121]

DEEMED MEASURE COST

The cost of this measure is assumed to be $100[122]

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

N/A

## Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS (NOTE WATER SAVINGS MUST FIRST BE CALCULATED)

$$\Delta kWH = \Delta Gallons \times 8.33 \times 1 \times (T_{out} - T_{in}) \times (1/EFF\ electric)\ /3{,}413 \times FLAG$$

Where:

| | |
|---|---|
| $\Delta Gallons$ | = amount of water saved as calculated below |
| 8.33 lbm/gal | = specific mass in pounds of one gallon of water |
| 1 Btu/lbm°F | = Specific heat of water: 1 Btu/lbm/°F |
| $T_{out}$ | = Water Heater Outlet Water Temperature |
| | = custom, otherwise assume $T_{in}$ + 70° F temperature rise from $T_{in}$[123] |
| $T_{in}$ | = Inlet Water Temperature |

---

[121] Reference 2010 Ohio Technical Reference Manual, Act on Energy Business Program Technical Reference Manual Rev05, and Federal Energy Management Program (2004), "How to Buy a Low-Flow Pre-Rinse Spray Valve."

[122] Costs range from $60 Chicagoland (Integrys for North Shore & People's Gas) to $150 referenced by Nicor's Resource Solutions Group Workpaper WPRSGCCODHW102 "Pre-Rinse Spray Valve." Act on Energy references $100.

[123] If unknown, assume a 70 degree temperature rise from $T_{in}$ per Food Service Technology Center calculator assumptions to account for variations in mixing and water heater efficiencies

= custom, otherwise assume 54.1 degree F[124]

EFF = Efficiency of electric water heater supplying hot water to pre-rinse spray valve

=custom, otherwise assume 97%[125]

Flag = 1 if electric or 0 if gas

---

**EXAMPLE**

Time of Sale:  For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.6 gal/min flow at a large institutional establishments with a cafeteria with 70 degree temperature rise of water used by the pre-rinse spray valve that is heated by electric hot water saves annually :

$\Delta$kWH = 30,326x 8.33 x 1 x ((70+54.1) - 54.1) x (1/.97) /3,413 x 1
= 5,181kWh

Retrofit:  For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.9 gal/min flow at a large institutional establishments with a cafeteria with 70 degree temperature rise of water used by the pre-rinse spray valve that is heated by electric hot water equals:

$\Delta$kWH = 47,175  x 8.33 x 1 x ((70+ 54.1) - 54.1) x (1/.97) /3,413 x 1
=8,060 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$\Delta$Therms = $\Delta$Gallons x 8.33 x 1 x (Tout - Tin) x (1/EFF) /100,000 Btu

Where (new variables only):

EFF = Efficiency of gas water heater supplying hot water to pre-rinse spray valve

= custom, otherwise assume 75%[126]

---

[124]August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor from Navigant states that 54.1°F was calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.
[125]This efficiency value is based on IECC 2009 performance requirement for electric resistant water heaters rounded without the slight adjustment allowing for reduction based on size of storage tank.
[126] IECC 2009, Table 504.2, Minimum Performance of Water-Heating Equipment

---

**EXAMPLE**

Time of Sale:  For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.6 gal/min flow at a large institutional establishments with a cafeteria with 70 degree temperature of water used by the pre-rinse spray valve that is heated by fossil fuel hot water saves annually:

ΔTherms     = 30,326 x 8.33 x 1 x ((70+54.1) - 54.1) x (1/.75)/100,000 x 1.0
            = 236 Therms

Retrofit:  For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.9 gal/min flow at a busy large institutional establishments with a cafeteria with 70 degree temperature rise of water used by the pre-rinse spray valve that is heated by fossil fuel hot water saves annually:

ΔTherms     = 47,175  x 8.33 x 1 x ((70+54.1) - 54.1) x (1/.75)/100,000 x (1-0)
            =368 Therms

---

**WATER IMPACT CALCULATION[127]**

ΔGallons = (FLObase - FLOeff)gal/min x 60 min/hr x HOURSday x DAYSyear

FLObase          = Base case flow in gallons per minute, or custom

| Time of Sale | Retrofit, Direct Install |
|---|---|
| 1.6 gal/min128 | 1.9 gal/min129 |

FLOeff            = Efficient case flow in gallons per minute or custom

| Time of Sale | Retrofit, Direct Install |
|---|---|
| 1.06 gal/min[130] | 1.06 gal/min[131] |

---

[127]In order to calculate energy savings, water savings must first be calculated

[128]The baseline equipment is assumed to be 1.6 gallons per minute.  The Energy Policy Act (EPAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03.  This performance standard went into effect January 1, 2006.  www1.eere.energy.gov/femp/pdfs/spec_prerinsesprayvavles.pdf.

[129] Verification measurements taken at 195 installations showed average pre and post flowrates of 2.23 and 1.12 gallon per minute, respectively." from  IMPACT AND PROCESS EVALUATION FINAL REPORT for CALIFORNIA URBAN WATER CONSERVATION COUNCIL 2004-5 PRE-RINSE SPRAY VALVE INSTALLATION PROGRAM (PHASE 2) (PG&E Program # 1198-04; SoCalGas Program 1200-04) ("CUWCC Report", Feb 2007)

[130]1.6 gallons per minute used to be the high efficiency flow, but more efficient spray valves are available ranging down to 0.64 gallons per minute per Federal Energy Management Program which references the Food Services Technology Center web site with the added note that even more efficient models may be available since publishing the data.  The average of the nozzles listed on the FSTC website is 1.06.

[131]1.6 gallons per minute used to be the high efficiency flow, but more efficient spray valves are available ranging down to 0.64 gallons per minute per Federal Energy Management Program which references the Food Services

---

HOURSday = Hours per day that the pre-rinse spray valve is used at the site, custom, otherwise[132]:

| Application | Hours/day |
|---|---|
| Small, quick- service restaurants | 1/2 |
| Medium-sized casual dining restaurants | 1.5 |
| Large institutional establishments with cafeteria | 3 |

DAYSyear = Days per year pre-rinse spray valve is used at the site, custom, otherwise 312 days/yr based on assumed 6 days/wk x 52 wk/yr = 312 day/yr.

---

**EXAMPLE**

Time of Sale:  For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.6 gal/min flow at a large institutional establishment with a cafeteria equals

= (1.6 – 1.06) * 60 * 3 * 312
= 30,326 gal/yr

Retrofit:  For example, a new spray nozzle with 106 gal/min flow replacing a nozzle with 1.9 gal/min flow at a large institutional establishments with a cafeteria equals

= (1.9 – 1.06) * 60 * 3 * 312
= 47,175 gal/yr

---

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-SPRY-V01-060112**

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Technology Center web site with the added note that even more efficient models may be available since publishing the data. The average of the nozzles listed on the FSTC website is 1.06.
[132] Hours primarily based on PG& E savings estimates, algorithms, sources (2005), Food Service Pre-Rinse Spray Valves with review of 2010 Ohio Technical Reference Manual and Act on Energy Business Program Technical Resource Manual Rev05.

## 6.2.12  Infrared Charbroiler

### DESCRIPTION

This measure applies to natural gas fired charbroilers that utilize infrared burners installed in a commercial kitchen

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas charbroiler with infrared burners.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas charbroiler without infrared burners.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[133]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $2200[134]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

---

**Algorithm**

### CALCULATION OF SAVINGS

### ELECTRIC ENERGY SAVINGS

N/A

---

[133]Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,   May 27, 2011
[134]Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 661 Therms.[135]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: **CI-FSE-IRCB-V01-060112**

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[135] Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

## 6.2.13  Infrared Rotisserie Oven

### DESCRIPTION

This measure applies to natural gas fired high efficiency rotisserie ovens utilizing infrared burners and installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas rotisserie oven with infrared burners.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas rotisserie oven without infrared burners.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[136]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $2700[137]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

---

[136]Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,   May 27, 2011
[137]Ibid.

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 554 Therms[138]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-IROV-V01-060112**

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[138]Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

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## 6.2.14 Infrared Salamander Broiler

### DESCRIPTION

This measure applies to natural gas fired high efficiency salamander broilers utilizing infrared burners installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas salamander broiler with infrared burners

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas salamander broiler without infrared burners

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[139]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $1000[140]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

---

[139]Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
[140]Ibid.

---

**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 239 therms[141]

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

MEASURE CODE: CI-FSE-IRBL-V01-060112

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[141] Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

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## 6.2.15 Infrared Upright Broiler

### DESCRIPTION

This measure applies to natural gas fired high efficiency upright broilers utilizing infrared burners and installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas upright broiler with infrared burners.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas upright broiler without infrared burners.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[142]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $5900[143]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

---

[142]Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
[143]Ibid.

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 1089 therms[144].

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IRUB-V01-060112

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[144] Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary

## 6.2.16  Kitchen Demand Ventilation Controls

### DESCRIPTION

Installation of commercial kitchen demand ventilation controls that vary the ventilation based on cooking load and/or time of day.

This measure was developed to be applicable to the following program types: TOS.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a   control system that varies the exhaust rate of kitchen ventilation (exhaust and/or makeup air fans) based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). This involves installing a new temperature sensor in the hood exhaust collar and/or an optic sensor on the end of the hood that sense cooking conditions which allows the system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed accordingly.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is kitchen ventilation that has constant speed ventilation motor.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[145]

### DEEMED MEASURE COST

The incremental capital cost for this measure is[146]

| Measure Category | Incremental Cost , $/fan |
|---|---|
| DVC Control Retrofit | $1,988 |
| DVC Control New | $1,000 |

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C23 - Commercial Ventilation

### COINCIDENCE FACTOR

The measure has deemed peak kW savings therefore a coincidence factor does not apply

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[145] PG&E Workpaper: Commercial Kitchen Demand Ventilation Controls-Electric, 2004  - 2005
[146] Ibid.

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**Algorithm**

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**CALCULATION OF SAVINGS**

Annual energy use was based on monitoring results from five different types of sites, as summarized in PG&E Food Service Equipment workpaper.

**ELECTRIC ENERGY SAVINGS**

The following table provides the kWh savings

| Measure Name | Annual Energy Savings Per Unit (kWh/fan) |
|---|---|
| DVC Control Retrofit | 4,486 |
| DVC Control New | 4,486 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

The following table provides the kW savings

| Measure Name | Coincident Peak Demand Reduction (kW) |
|---|---|
| DVC Control Retrofit | 0.76 |
| DVC Control New | 0.76 |

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-VENT-V01-060112**

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## 6.2.17 Pasta Cooker

### DESCRIPTION

This measure applies to natural gas fired dedicated pasta cookers as determined by the manufacturer and installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas fired paste cooker.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas fired stove where pasta is cooked in a pan.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12[147].

### DEEMED MEASURE COST

The incremental capital cost for this measure is $2400[148].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

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[147]Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011
[148]Ibid.

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 1380 Therms[149].

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-FSE-PCOK-V01-060112**

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[149]Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

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## 6.2.18 Rack Oven - Double Oven

### DESCRIPTION

This measure applies to natural gas fired high efficiency rack oven - double oven installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas rack oven –double oven with a baking efficiency ≥ 50% utilizing ASTM standard 2093

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas rack oven – double oven with a baking efficiency < 50%.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.[150]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $8646.[151]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

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[150]Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011

[151]Ibid.

---

**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 2064 therms[152]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

**MEASURE CODE: CI-FSE-RKOV-V01-060112**

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[152]Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary

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## 6.3 Hot Water

### 6.3.1 Storage Water Heater

**DESCRIPTION**

This measure is for upgrading from minimum code to a storage-type water heaters. Storage water heaters are used to supply hot water for a variety of commercial building types. Storage capacities vary greatly depending on the application. Large consumers of hot water include (but not limited to) industries, hotels/motels and restaurants.

This measure was developed to be applicable to the following program types: TOS, RF, ER.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

| Gas, High Efficiency | Gas, Standard | Electric |
|---|---|---|
| In order for this characterization to apply, the efficient equipment is assumed to have heating capacity over 75,000 Btuh and a Thermal Efficiency (TE) greater than or equal to 88% | In order for this characterization to apply, the efficient equipment is assumed to be a gas-fired storage water heaters with 0.67 EF or better installed in a non-residential application<br><br>Primary applications would include (but not limited to) hotels/motels, small commercial spaces, offices and restaurants | In order for this characterization to apply, the efficient equipment is assumed to have[153].:<br>Energy factor greater than or equal to 0.95 Minimum Thermal Efficiency of 0.98<br><br>Less than 3% standby loss (standby loss is calculated as percentage of annual (energy usage)<br><br>Equivalent storage capacity to unit being replaced<br><br>Qualified units must be GAMA/AHRI efficiency rating certified |

**DEFINITION OF BASELINE EQUIPMENT**

| Gas, High Efficiency | Gas, Standard | Electric |
|---|---|---|
| In order for this characterization to apply, the baseline condition is assumed to be a water heater with heating capacity over 75,000 Btuh and a Thermal Efficiency (TE) of 80% | In order for this characterization to apply, the baseline condition is assumed to be the minimum code compliant unit with 0.575 EF. | In order for this characterization to apply, the baseline equipment is assumed to be an electric storage water heater with 50 or more gallon capacity in input wattage between 12kW and 54kW. |

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[153] Act on Energy Commercial Technical Reference Manual No. 2010-4

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

| Gas, High Efficiency | Gas, Standard | Electric |
|---|---|---|
| The expected measure life is assumed to be 15 Years[154] | The expected measure life is assumed to be 15 years[155] | The expected measure life is assumed to be 5 years[156]. |

**DEEMED MEASURE COST**

| Gas, High Efficiency | Gas, Standard | Electric |
|---|---|---|
| The incremental capital cost for this measure is $209[157] | The deemed measure cost is assumed to be $400[158] | The incremental capital cost for this measure is assumed to be[159] |

Electric column table:

| Tank Size | Incremental Cost |
|---|---|
| 50 gallons | $1050 |
| 80 gallons | $1050 |
| 100 gallons | $1950 |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

| Gas, High Efficiency | Gas, Standard | Electric |
|---|---|---|
| N/A | N/A | Loadshape C02 - Non-Residential Electric DHW |

**COINCIDENCE FACTOR**

| Gas, High Efficiency | Gas, Standard | Electric |
|---|---|---|
| N/A | N/A | The measure has deemed kW savings therefor a coincidence factor is not applied |

---

[154] Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011

[155] Gas Storage Water Heater 0.67. Work Paper WPRSGNGDHW106. Resource Solutions Group. December 2010

[156] Ibid.

[159] Ibid.

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS** [160]

The annual electric savings the electric water storage tank and heater is a deemed value and assumed to be:

| Tank Size | Savings (kWh) |
| --- | --- |
| 50 gallons | 1780.85 |
| 80 gallons | 4962.69 |
| 100 gallons | 8273.63 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS** [161]

The annual kW savings from this measure is a deemed value and assumed to be:

| Tank Size | Savings (kW) |
| --- | --- |
| 50 gallons | 0.20 |
| 80 gallons | 0.57 |
| 100 gallons | 0.94 |

---

[160] Ibid.
[161] Ibid.

---

**NATURAL GAS ENERGY SAVINGS**

| Gas, High Efficiency | Gas, Standard | |
|---|---|---|
| The annual natural gas energy savings from this measure is a deemed value equaling 251[162] | Gas savings depend on building type and are based on measure case energy factor of 0.67 and a heating capacity of 75 MBtuh. These values are averages of qualifying units. Savings values are derived from 2008 DEER Miser, which provides MBtuh gas savings per MBtuh capacity. Savings presented here are per water heater.[163] | |
| | Building Type | Energy Savings (therms/unit) |
| | Assembly | 185 |
| | Education – Primary/Secondary | 124 |
| | Education – Post Secondary | 178 |
| | Grocery | 191 |
| | Health/Medical - Hospital | 297 |
| | Lodging - Hotel | 228 |
| | Manufacturing - Light Industrial | 140 |
| | Office – > 60,000 sq-ft | 164 |
| | Office – < 60,000 sq-ft | 56 |
| | Restaurant - FastFood | 109 |
| | Restaurant – Sit Down | 166 |
| | Retail | 105 |
| | Storage | 150 |
| | Multi-Family | 119 |
| | Other | 148 |

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HW_-STWH-V01-060112**

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[162] Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary

[163] Gas Storage Water Heater 0.67. Work Paper WPRSGNGDHW106. Resource Solutions Group. December 2010

## 6.3.2    Low Flow Faucet Aerators

**DESCRIPTION**

This measure relates to the direct installation of a low flow faucet aerator in a kitchen or bath faucet fixture in a commercial building. Expected applications include small business, office, restaurant, or motel. For multifamily or senior housing, the residential low flow faucet aerator should be used.

This measure was developed to be applicable to the following program types, DI.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be an energy efficient faucet aerator, for bathrooms rated at 1.5 gallons per minute (GPM) or less, or for kitchens rated at 2.2 GPM or less. Savings are calculated on an average savings per faucet fixture basis.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or more, or a standard kitchen faucet aerator rated at 2.75 GPM or more.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 9 years.[164]

**DEEMED MEASURE COST**

The incremental cost for this measure is $8[165] or program actual

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C02 - Commercial Electric DHW

**COINCIDENCE FACTOR**

The coincidence factor for this measure is assumed to be 2.2%[166]

---

[164] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
"http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"
[165] Direct-install price per faucet assumes cost of aerator and install time. (2011, Market research average of $3 and assess and install time of $5 (20min @ $15/hr)
[166] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on:
http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-

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---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

**NOTE THESE SAVINGS ARE *PER* FAUCET RETROFITTED**[167]**.**

ΔkWh  = %ElectricDHW  * ((GPM_base * L_base - GPM_low * L_low) * NOPF* 365.25 *DF / GPMfactor) * EPG_electric * ISR

Where:

%ElectricDHW       = proportion of water heating supplied by electric resistance heating

| DHW fuel | %Electric_DHW |
|----------|---------------|
| Electric | 100% |
| Fossil Fuel | 0% |
| Unknown | 16%[168] |

NOPF     = Number of occupants per faucet. For example if there is an office with 20 people and 4 faucets total, the number of people per faucet is 5.This assumes that all faucets in count, have been retrofitted with low flow.

| Occupant input | Number |
|----------------|--------|
| Custom | Estimated number of people using the faucet |

365.25               = Days in a year, on average.

---

Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365.25 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% * 180= 5.8 hours of recovery during peak period. There are 180 hours in the peak period so the probability you will see savings during the peak period is 5.8/180= 0.022

[167] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.  Due to the distribution of water consumption by fixture type, as well as the different number of fixtures in a biulding, several variables must be incorporated.

[168] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

DF  = Drain Factor

| Faucet Type | Drain Factor[169] |
|---|---|
| Kitchen | 75% |
| Bath | 90% |
| Unknown | 79.5% |

GPM_base  = Average flow rate, in gallons per minute, of the baseline faucet "as-used"

= 1.2[170] or custom based on metering studies[171]

GPM_low  = = Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used"

= 0.94[172] or custom based on metering studies[173]

L_base  = Average baseline length faucet use per capita for all faucets in minutes

= 9.85 min/person/day[174] or custom based on metering studies

L_low  = Average retrofit length faucet use per capita for all faucets in minutes

---

[169] Because faucet usages are at times dictated by volume, it is assumed only half of the kitchen usage is of the sort that would go straight down the drain. VEIC is unaware of any metering study that has determined this specific factor and so through consensus with the Illinois Technical Advisory Group have deemed these values to be 75% for the kitchen and 90% for the bathroom. If the aerator location is unknown an average of 79.5% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7*0.75)+(0.3*0.9)=0.795.

[170] Representative baseline flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use.

[171] Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

[172] Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. Assumes all kitchen aerators at 2.2 gpm or less and all bathroom aerators at 1.5 gpm or less. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use. It is possible that programs installing low flow aerators lower than the 2.2 gpm for kitchens and 1.5 gpm for bathrooms will see a lower overall average retrofit flow rate.

[173] Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

[174] This coincides with the middle of the range (6.74 min/per/day to 13.4 min/per/day) from sources 2, 3, 4, and 5 (See Source Table at end of measure section). A recent Midwest evaluation study included a small metering sample with measured faucet use at 4.5 min/per/day for kitchen faucets and 2.6 min/per/day for bathroom faucets. This sample was too small to extrapolate to the population as a whole, but is within the range of total faucet time per the referenced reports and confirms previous findings.

= 9.85 min/person/day[175] or custom based on metering studies

GPMfactor = Factor that normalizes flow to each faucet.[176]

| Faucet Type | FPH |
|-------------|-----|
| Kitchen | 1 |
| Bath | 2.5 |

EPG_electric = Energy per gallon of water used by faucet supplied by electric water heater

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_electric * 3412)

= (8.33 * 1.0 * (90 – 54.1)) / (0.98 * 3412)

= 0.0894 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb-F)

WaterTemp = Assumed temperature of mixed water

= 90F [177]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [178]

RE_electric = Recovery efficiency of electric water heater

= 98% [179]

3412 = Converts Btu to kWh (btu/kWh)

---

[175] Set equal to L_base. Studies show conflicting results with some studies showing increased time for retrofit homes and some showing decreased time. Engineering judgment leads us to conclude that using the baseline time is a reasonable assumption.

[176] This factor modifies the residential faucet aerator to be used in a commercial setting. This calculation assumes that the faucets in commercial facilities have similar use with respect to on/off cycle

[177] Temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm. This is a variable that would benefit from further evaluation.

[178] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

[179] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

ISR = In service rate of faucet aerators dependant on install method as listed in table below[180]

| Selection | ISR |
|---|---|
| Direct Install - Deemed | 0.95 |

---

**EXAMPLE**

For example, a direct installed faucet in an office with electric DHW, 4 faucets and 20 office occupants (savings per faucet):

ΔkWh = 1 *((1.2*9.85-0.94*9.85)*(20/4)*365.25*.795)/(1+2.5))*.0894*.95

= 90.22 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = ΔkWh / Hours * CF

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

= ((GPM_base * L_base) * 365.25 * DF ) * 0.545[181] /GPH

=14.73

Where :

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.022[182].

---

[180] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8

[181] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

[182] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of

**EXAMPLE**

For example, a direct installed faucet in an office with electric DHW:

$$\Delta kW = 90.22/14.73 * 0.032$$

$$= .196\ kW$$

**FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION**

$$\Delta Therms = \%FossilDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * NOPF * 365.25 * DF )/FPH) * EPG\_gas * ISR$$

Where:

%FossilDHW     = proportion of water heating supplied by fossil fuel heating

| DHW fuel | %Fossil_DHW |
|----------|-------------|
| Electric | 0% |
| Fossil Fuel | 100% |
| Unknown | 84%[183] |

EPG_gas     = Energy per gallon of Hot water supplied by gas

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_gas * 100,000)

= 0.0045 Therm/gal for MF homes

---

total annual aerator use in peak period is 0.18*65/365.25 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

[183] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

Where:

RE_gas            = Recovery efficiency of gas water heater

`                 = 67% [184]

100,000           = Converts Btus to Therms (btu/Therm)

Other variables as defined above.

---

**EXAMPLE**

For example, a direct installed bath faucet in an office with gas DHW, 4 faucets and 20 office occupants (savings per faucet):

ΔTherms            = 1  ((1.2*9.85) – (.94*9.85))* 20/4* 365.25 *0.795) /(1+2.5))0.0045 * 0..95

= 4.54Therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

Δgallons =

((GPM_base * L_base - GPM_low * L_low) * NFPO * 365.25 *DF / FPH) * ISR

Variables as defined above

---

**EXAMPLE**

For example, a direct installed 1 faucet in an office, 4 faucets and 20 office occupants (savings per faucet

Δgallons = ((1.2*9.82)-(0.94*9.85))*(20/4)*365.25*.795/(1+2.5 * 0.95

= 1009.2 gallons

---

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

---

[184] 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%.  Commercial properties are more similar to MF homes than SF homes.  MF hot water is often provided by a larger commercial boiler.  This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for signle family home.  An average is used for this analysis by default.

SOURCES

| Source ID | Reference |
|---|---|
| 1 | 2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011. |
| 2 | 2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000. |
| 3 | 1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999. |
| 4 | 2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003. |
| 5 | 2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011. |
| 6 | 2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011. |
| 7 | 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. |

MEASURE CODE: CI-HW_-LFFA-V01-060112

## 6.3.3   Low Flow Showerheads

**DESCRIPTION**

This measure relates to the direct installation of a low flow showerhead in a commercial building. Expected applications include small business, office, restaurant, or small motel. For multifamily or senior housing, the residential low flow showerhead should be used.

This measure was developed to be applicable to the following program types:  DI.
If applied to other program types, the measure savings should be verified

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be an energy efficient showerhead rated at 2.0 gallons per minute (GPM) or less. Savings are calculated on a per showerhead fixture basis.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is assumed to be a standard showerhead rated at 2.5 GPM.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 10 years.[185]

**DEEMED MEASURE COST**

The incremental cost for this measure is $12[186] or program actual.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C02 - Commercial Electric DHW

**COINCIDENCE FACTOR**

The coincidence factor for this measure is assumed to be 2.78%[187].

---

[185] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.  Evaluations indicate that consumer dissatisfaction may lead to reductions in persistence, particularly in Multi-Family , "http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"

[186] Direct-install price per showerhead assumes cost of showerhead (Market research average of $7 and assess and install time of $5 (20min @ $15/hr)

[187] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak

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**Algorithm**

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### CALCULATION OF SAVINGS [188]

### ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

$\Delta kWh$ =

%ElectricDHW  * ((GPM_base * L_base - GPM_low * L_low) * NSPD * 365.25/GPMfactor) * EPG_electric * ISR

Where:

| | |
|---|---|
| %ElectricDHW | = proportion of water heating supplied by electric resistance heating |
| | = 1 if electric DHW, 0 if fuel DHW, if unknown assume 16% [189] |
| GPM_base | = Flow rate of the baseline showerhead |
| | = 2.67 for Direct-install programs[190] |
| GPM_low | = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaulations deviate from rated flows, see table below: |

| Rated Flow |
|---|
| 2.0 GPM |
| 1.75 GPM |
| 1.5 GPM |
| Custom or Actual[191] |

| | |
|---|---|
| L_base | = Shower length in minutes with baseline showerhead |
| | = 8.20 min[192] |
| L_low | = Shower length in minutes with low-flow showerhead |

---

periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7,23/260 = 0..0278

[188]Based on excel spreadsheet 120911.xls …on SharePoint

[189] Table HC8.9. Water Heating in U.S. Homes in Midwest Region, Divisions, and States,  2009 (RECS)

[190] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

[191] Note that actual values may be either a) program-specific minimum flow rate, or b)program-specific evaluation-based value of actual effective flow-rate due to increased duration or temperatures. The latter increases in likelihood as the rated flow drops and may become significant at or below rated flows of 1.5 GPM. The impact can be viewed as the inverse of the throttling described in the footnote for baseline flowrate.

[192] Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)

---

= 8.20 min[193]

GPMFactor = Factor that normalizes flow to each showerhead.[194]

=1.6

365.25 = Days per year, on average.

NSPD = Estimated number of showers taken per day for one showerhead

EPG_electric = Energy per gallon of hot water supplied by electric

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3412)

= (8.33 * 1.0 * (105 – 54.1)) / (0.98 * 3412)

= 0.127 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb-F)

ShowerTemp = Assumed temperature of water

= 105F [195]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [196]

RE_electric = Recovery efficiency of electric water heater

= 98% [197]

3412 = Converts Btu to kWh (btu/kWh)

---

[193] Set equal to L_base.

[195] Shower temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm
[196] US DOE Building America Program. Building America Analysis Spreadsheet.  For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
[197] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

ISR                     = In service rate of showerhead

                        = Dependant on program delivery method as listed in table below

| Selection | ISR[198] |
|---|---|
| Direct Install - Deemed | 0.98 |

---

**EXAMPLE**

For example, a direct-installed 1.5 GPM showerhead in an office with electric DHW where the number of showers is estimated at 3 per day:

ΔkWh    = (1 ((2.67*8.20)- (1.5*8.20)) * 3*365.25/1.6) *0.127 * 0.98

            = 818kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW  = ΔkWh/Hours * CF

Where:

ΔkWh    = calculated value above

Hours    = Annual electric DHW recovery hours for showerhead use

            = ((GPM_base * L_base) *NSPD * 365.25 ) * 0.773[199] / GPH

Where:

GPH        = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

            = 27.51

CF        = Coincidence Factor for electric load reduction

            0.0278[200]

---

[198] Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.
[199] 77.3% is the proportion of hot 120F water mixed with 54.1F supply water to give 105F shower water.
[200] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-

---

**EXAMPLE**

For example, a direct-installed 1.5 GPM showerhead in an office with electric DHW where the number of showers is estimated at 3 per day:

ΔkW    = 818/((2.67 * 8.20) *3*365.25)*.773/27.51) * 0.0278

= 0.033kW

---

**FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION**

ΔTherms    = %FossilDHW * * ((GPM_base * L_base - GPM_low * L_low) * NSPD* 365.25/GPMfactor) * EPG_gas * ISR

Where:

%FossilDHW    = proportion of water heating supplied by fossil fuel heating

| DHW fuel | %Fossil_DHW |
|----------|-------------|
| Electric | 0% |
| Fossil Fuel | 100% |
| Unknown | 84%[201] |

EPG_gas    = Energy per gallon of Hot water supplied by gas

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_gas * 100,000)

= 0.0063 Therm/gal

Where:

RE_gas    = Recovery efficiency of gas water heater

= 67% [202]

100,000    = Converts Btus to Therms (btu/Therm)

---

[Family-Homes-Using-Flow-Trace-Analysis.pdf](#)). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365.25 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

[201] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[202] 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%.  Commercial properties are more similar to MF homes than SF homes.  MF hot water is often provided by a larger commercial boiler.  This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for signle family home.  An average is used for this analysis by default.

---

Other variables as defined above.

---

**EXAMPLE**

For example, a direct-installed 1.5 GPM showerhead in an office with gas DHW where the number of showers is estimated at 3 per day:

ΔTherms          = 1.0 *(( 2.67 *8,2) – (1.5 * 8.2))*3*365.25)/1.6)* 0.0063* 0.98

                 = 40.6therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * NSPD * 365.25  * ISR

Variables as defined above

---

**EXAMPLE**

For example, a direct-installed 1.5 GPM showerhead in an office with where the number of showers is estimated at 3 per day:

Δgallons ((2.67*8.20)-(1.5*8.20))*3*365.25*.98

          = 10,302 gallons

---

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**SOURCES**

| Source ID | Reference |
|---|---|
| 1 | 2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011. |
| 2 | 2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000. |
| 3 | 1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999. |
| 4 | 2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003. |
| 5 | 2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011. |
| 6 | 2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011. |
| 7 | 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. |

**MEASURE CODE: CI-HW_-LFSH-V01-060112**

## 6.3.4   Tankless Water Heater

### DESCRIPTION

This measure covers the installation of on-demand tankless or instantaneous water heater. Tankless water heaters function similar to standard hot water heaters except they do not have a storage tank.  When there is a call for hot water, and the water is heated as it passes through the heater to the user or appliance calling for hot water. Tankless water heaters achieve savings by eliminating the standby losses that occur in stand-alone or tank-type water heaters and by being more efficient than the baseline storage hot water heater.

This measure was developed to be applicable to the following program types:  TOS, RF, ER.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

| | |
|---|---|
| In order for this characterization to apply, the efficient equipment is assumed to be electric powered with[203]:<br><br>• Energy factor greater than or equal to 0.95<br>• Minimum Thermal Efficiency of 0.98<br>• Less than 3% standby loss (standby loss is calculated as percentage of annual (energy usage)<br>• Equivalent storage capacity to unit being replaced Qualified units must be GAMA/AHRI efficiency rating certified. | To qualify for this measure, the tankless water heater shall meet or exceed the efficiency requirements for tankless hot water heaters mandated by the International Energy Conservation Code (IECC) 2009, Table 504.2. |

### DEFINITION OF BASELINE EQUIPMENT

| Electric | Gas |
|---|---|
| In order for this characterization to apply, the baseline equipment is assumed to be an electric storage water heater with 50 or more gallon capacity in input wattage between 12kW and 54kW. | The baseline condition is assumed to be a gas-fired tank-type water heater meeting the efficiency requirements mandated by the International Energy conservation Code (IECC) 2009, Table 504.2. |

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

| Electric | Gas |
|---|---|
| The expected measure life is assumed to be 5 years[204]. | The expected measure life is assumed to be 20 years[205] |

---

[203] Act on Energy Commercial Technical Reference Manual No. 2010-4
[204] Ibid.
[205] Ohio Technical Reference Manual 8/2/2010 referencing CenterPoint Energy-Triennial CIP/DSM Plan 2010-2012 Report; Additional reference stating >20 years is at Energy Savers.Gov online at http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820

**DEEMED MEASURE COST**

The incremental capital cost for an electric tankless heater this measure is assumed to be[206]

| Tank Size | Incremental Cost |
|---|---|
| 50 gallons | $1050 |
| 80 gallons | $1050 |
| 100 gallons | $1950 |

The incremental capital cost for a gas fired tankless heater  is as follows:

| Program | Capital Cost, $ per unit |
|---|---|
| Retrofit | $871.74[207] |
| Time of Sale or New Construction | $433.72[208] |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C02 - Commercial Electric DHW

**COINCIDENCE FACTOR**

The measure has deemed kW savings therefor a coincidence factor is not applied

---

**Algorithm**

---

**CALCULATION OF ENERGY SAVINGS**

---

[206] Ibid.

[207] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008 as referenced in Ohio Techical Reference Manual dated August 6, 2010.

[208] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008 as referenced in Ohio Techical Reference Manual dated August 6, 2010.

**ELECTRIC ENERGY SAVINGS** [209]

The annual electric savings from an electric tankless heater is a deemed value and assumed to be:

| Tank Size | Savings (kWh) |
|---|---|
| 50 gallons | 1780.85 |
| 80 gallons | 4962.69 |
| 100 gallons | 8273.63 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS** [210]

The annual kW savings from an electric tankless heater is a deemed value and assumed to be:

| Tank Size | Savings (kW) |
|---|---|
| 50 gallons | 0.20 |
| 80 gallons | 0.57 |
| 100 gallons | 0.94 |

**NATURAL GAS ENERGY SAVINGS**

$\Delta$Therms=[[W x 8.33 x 1 x (Tout - Tin) x [(1/Eff base) - (1/Eff ee)]]/100,000] +[[(SL x 8,766)/Eff base]] / 100,000 Btu/Therms]

Where:

$W_{gal}$ = Annual water use for equipment in gallons

= custom, otherwise assume 21,915 gallons [211]

8.33 lbm/gal = weight in pounds of one gallon of water

1 Btu/lbm°F = Specific heat of water: 1 Btu/lbm/°F

8,766 hr/yr = hours a year

Tout = Unmixed Outlet Water Temperature

= custom, otherwise assume 130 degree F[212]

Tin = Inlet Water Temperature

= custom, otherwise assume 54.1 degree F[213]

---

[209] Ibid.

[210] Ibid.

[211] 21,915 gallons is an estimate of 60 gal/day for 365.25 days/yr. If building type is known, reference 2007 ASHRAE Handbook HVAC Applications p. 49.14 Table 7 Hot Water Demands and Use for Various Types of Buildings to help estimate hot water consumption.

[212] Based on 2010 Ohio Techical Reference Manual and NAHB Research Center, (2002) Performance Comparison of Residential hot Water Systems. Prepared for National Renewable Energy Laboratory, Golden, Colorado.

Eff base = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et); see table below[214]

| Eff base | Performance Baseline | Units |
|---|---|---|
| Size: ≤ 75,000 Btu/h | 0.67 - 0.0019*Tank Volume | Energy Factor |
| Size: >75,000 Btu/h and ≤ 155,000 Btu/h | 80% | Thermal Efficiency |
| Size: >155,000 Btu/h | 80% | Thermal Efficiency |

Where Tank Volume = custom input, if unknown assume 60 gallons for Size: ≤ 75,000 Btu/h

Please note:  Units in base case must match units in efficient case.  If Energy Factor used in base case, Energy Factor to be used in efficient case.  If Themal Efficiency is used in base case, Thermal Efficiency must be used in efficient case.

Eff ee = Rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (Eff t)

= custom input, if unknown assume 0.84[215]

SL = Stand-by Loss in Base Case Btu/hr

= custom input based on formula in table below, if unknown assume unit size in table below[216]

| Eff base | Standby Loss (SL) |
|---|---|
| Size: ≤ 75,000 Btu/h | 0 |
| Size: >75,000 Btu/h | (Input rating/800)+(110*√Tank Volume)) |

Where:

Tank Volume = custom input, if unknown assume, 60 gallons for <75,000 Btu/hr,  75 gallons for >75,000 Btu/h and ≤ 155,000 Btu/h and 150 for Size  >155,000 Btu/h

---

[213] August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor from Navigant states that 54.1°F was calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.

[214] IECC 2009, Table 504.2, Minimum Performance of Water-Heating Equipment

[215] Specifications of energy efficient tankless water heater.  Reference Consortium for Energy Efficiency (CEE) which maintains a list of high efficiency tankless water heaters which currently have Energy Factors up to .96. Ameren currently requires minimum .82 energy factor.

[216] Stand-by loss is provided 2009 International Energy Conservation Code (IEytqqC 2009), Table 504.2, Minimum Performance of Water-Heating Equipment

Input Value = nameplate Btu/hr rating of water heater

---

**EXAMPLE**

For example, a 75,000 Btu/h tankless unit using 21,915 gal/yr with outlet temperature at 130.0 and inlet temperature at 54.1, replacing a baseline unit with 0.8 thermal efficiency and standby losses of 1008.3 btu/hr :

$\Delta$Therms  =[[(21,915 x 8.33x  1  x (130 – 54.1) x [(1/.8) - (1/.84)]/100,000] +[(1008.3  x 8,766)/.8]] / 100,000
=115 Therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

The deemed O&M cost adjustment for a gas fired tankless heater is $9.60[217]

**MEASURE COST: CI-HW_-TKWH-V01-060112**

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[217] "Center Point Energy – Triennial CIP/DSM Plan 2010 – 2012 Report"

## 6.4 HVAC End Use

### 6.4.1 Air Conditioner Tune-up

**DESCRIPTION**

An air conditioning system that is operating as designed saves energy and provides adequate cooling and comfort to the conditioned space

**DEFINITION OF EFFICIENT EQUIPMENT**

In order for this characterization to apply, the efficient equipment is assumed to be a unitary or split system air conditioner least 3 tons and preapproved by program. The measure requires that a certified technician performs the following items:

- · Check refrigerant charge
- · Identify and repair leaks if refrigerant charge is low
- · Measure and record refrigerant pressures
- · Measure and record temperature drop at indoor coil
- · Clean condensate drain line
- · Clean outdoor coil and straighten fins
- · Clean and straighten indoor and outdoor fan blades
- · Clean indoor coil with spray-on cleaner and straighten fins
- · Repair damaged insulation – suction line
- · Change air filter
- · Measure and record blower amp draw
- · Measure and record compressor integrity (MOhm)
- · Measure and record condenser fan motor amp draw

A copy of contractor invoices that detail the work performed to identify tune-up items, as well as additional labor and parts to improve/repair air conditioner performance must be submitted to the program

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline condition is assumed to be an AC system that that does not have a standing maintenance contract or a tune up within in the past 36 months.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 3 years.[218]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $35[219] per ton.

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[218] Act on Energy Commercial Technical Reference Manual No. 2010-4
[219] Ibid.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C03 - Commercial Cooling

**COINCIDENCE FACTOR**

The measure has deemed peak kW savings therefore a coincidence factor does not apply

| Algorithm |
|---|

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value of 878 kWh a year.[220]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value 0.39 kW a year.[221]

**NATURAL GAS ENERGY SAVINGS**

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

**DEEMED O&M COST ADJUSTMENT CALCULATION**

**MEASURE CODE: CI-HVC-ACTU-V01-060112**

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[220]Ibid.

[221]Act on Energy Commercial Technical Reference Manual No. 2010-4. These deemed values should be compared to PY evaluation and revised as necessary.

## 6.4.2   Space Heating Boiler Tune-up [222]

### DESCRIPTION

This measure is for a non-residential boiler that provides space heating.  The tune-up will improve boiler efficiency by cleaning and/or inspecting burners, combustion chamber, and burner nozzles.  Adjust air flow and reduce excessive stack temperatures, adjust burner and gas input.  Check venting, safety controls, and adequacy of combustion air intake.  Combustion efficiency should be measured before and after tune-up using an electronic flue gas analyzer.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[223] listed below, by approved technician:

- Measure combustion efficiency using an electronic flue gas analyzer
- Adjust airflow and reduce excessive stack temperatures
- Adjust burner and gas input, manual or motorized draft control
- Check for proper venting
- Complete visual inspection of system piping and insulation
- Check safety controls
- Check adequacy of combustion air intake
- Clean fireside surfaces.
- Inspect all refractory. Patch and wash coat as required.
- Inspect gaskets on front and rear doors and replace as necessary.
- Seal and close front and rear doors properly.
- Clean low and auxiliary low water cut-off controls, then re-install using new gaskets.
- Clean plugs in control piping.
- Remove all hand hole and man hole plates. Flush boiler with water to remove loose scale and sediment.
- Replace all hand hole and man hole plates with new gaskets.
- Open feedwater tank manway, inspect and clean as required. Replace manway plate with new gasket.
- Clean burner and burner pilot.
- Check pilot electrode and adjust or replace.
- Clean air damper and blower assembly.
- Clean motor starter contacts and check operation.
- Make necessary adjustments to burner for proper combustion.
- Perform all flame safeguard and safety trip checks.
- Check all hand hole plates and man hole plates for leaks at normal operating temperatures and pressures.
- Troubleshoot any boiler system problems as reQuested by on-site personnel

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition of this measure is the facility cannot have standing maintenance contract or tune-up within the past 36 months

---

[222]High Impact Measure

[223]Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 3 years[224]

**DEEMED MEASURE COST**

The cost of this measure is $0.83/MBtuh[225] per tune-up

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

**Algorithm**

---

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$$\Delta therms = Ngi * SF * EFLH/(Effpre * 100))$$

Where:

Ngi = Boiler gas input size (kBTU/hr)

= custom

SF = Savings factor

Note: Savings factor is the percentage reduction in gas consumption as a result of the

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[224]Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[225]Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

tune-up

= 1.6%[226] or custom

EFLH    = Equivalent Full Load Hours for heating[227]

| Building Type | EFLH | | | | |
|---|---|---|---|---|---|
| | Zone 1 (Rockford) | Zone 2 (Chicago) | Zone 3 (Springfield) | Zone 4 (Belleville/ | Zone 5 (Marion) |
| Office - High Rise | 2,746 | 2,768 | 2,656 | 2,155 | 2,420 |
| Office - Mid Rise | 996 | 879 | 824 | 519 | 544 |
| Office - Low Rise | 797 | 666 | 647 | 343 | 329 |
| Convenience | 696 | 550 | 585 | 272 | 297 |
| Healthcare Clinic | 1,118 | 1,036 | 1,029 | 694 | 737 |
| Manufacturing Facility | 1,116 | 1,123 | 904 | 771 | 857 |
| Lodging Hotel/Motel | 2,098 | 2,050 | 1,780 | 1,365 | 1,666 |
| High School | 969 | 807 | 999 | 569 | 674 |
| Hospital | 2,031 | 1,929 | 1,863 | 1,497 | 1,800 |
| Elementary | 970 | 840 | 927 | 524 | 637 |
| Religious Facility | 1,830 | 1,657 | 1,730 | 1,276 | 1,484 |
| Restaurant | 1,496 | 1,379 | 1,291 | 872 | 1,185 |
| Retail - Strip Mall | 1,266 | 1,147 | 1,151 | 732 | 863 |
| Retail - Department Store | 1,065 | 927 | 900 | 578 | 646 |
| College/University | 373 | 404 | 376 | 187 | 187 |
| Warehouse | 416 | 443 | 427 | 226 | 232 |
| Unknown | 1,249 | 1,163 | 1,130 | 786 | 910 |

Effpre    = Boiler Combustion Efficiency Before Tune-Up

= 80%[228] or custom

---

[226]Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010
[227]Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types:  office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models werer those developed for IL lighting interactive effects.
[228]Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

---

**EXAMPLE**

For example, a 1050  kBtu boiler in  Chicago at a high rise office:

$$\Delta therms = 1050 *.016 * 2768/ (0.80 * 100))$$
$$= 581 \text{ therms}$$

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-BLRT-V01-060112**

## 6.4.3   Process Boiler Tune-up[229]

**DESCRIPTION**

This measure is for a non-residential boiler for process loads.  For space heating, see measure 5.2.1.  .The tune-up will improve boiler efficiency by cleaning and/or inspecting burners, combustion chamber, and burner nozzles. Adjust air flow and reduce excessive stack temperatures, adjust burner and gas input.  Check venting, safety controls, and adequacy of combustion air intake.  Combustion efficiency should be measured before and after tune-up using an electronic flue gas analyzer.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[230] by approved technician, as specified below:

- • Measure combustion efficiency using an electronic flue gas analyzer
- • Adjust airflow and reduce excessive stack temperatures
- • Adjust burner and gas input, manual or motorized draft control
- • Check for proper venting
- • Complete visual inspection of system piping and insulation
- • Check safety controls
- • Check adequacy of combustion air intake
- • Clean fireside surfaces
- • Inspect all refractory. Patch and wash coat as required.
- • Inspect gaskets on front and rear doors and replace as necessary.
- • Seal and close front and rear doors properly.
- • Clean low and auxiliary low water cut-off controls, then re-install using new gaskets.
- • Clean plugs in control piping.
- • Remove all hand hole and man hole plates. Flush boiler with water to remove loose scale and sediment.
- • Replace all hand hole and man hole plates with new gaskets.
- • Open feedwater tank manway, inspect and clean as required. Replace manway plate with new gasket.
- • Clean burner and burner pilot.
- • Check pilot electrode and adjust or replace.
- • Clean air damper and blower assembly.
- • Clean motor starter contacts and check operation.
- • Make necessary adjustments to burner for proper combustion.
- • Perform all flame safeguard and safety trip checks.
- • Check all hand hole plates and man hole plates for leaks at normal operating temperatures and pressures.
- • Troubleshoot any boiler system problems as reQuested by on-site personnel

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition of this measure is the facility cannot have standing maintenance contract or tune-up within the past 36 months

---

[229]High Impact Measure

[230]Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 3 years[231]

**DEEMED MEASURE COST**

The cost of this measure is $0.83/MBtuh[232] per tune-up

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

**Algorithm**

---

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$$\Delta therms = ((Ngi * 8766 * UF)/100) * (1 - (Eff_{pre}/Eff_{measured}))$$

Where:

Ngi    = Boiler gas input size (kBTU/hr)

        = custom

UF    = Utilization Factor

        = 41.9%[233] or custom

---

[231]Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

[232]Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

$Eff_{pre}$ = Boiler Combustion Efficiency Before Tune-Up

= 80%[234] or custom

$Eff_{measured}$ = Boiler Combustion Efficiency After Tune-Up

= 81.3%[235] or custom

---

**EXAMPLE**

For example, a 1050 kBtuboiler:

$$\Delta therms = (1050 * 8766 * .419)/100)*(1-*(0.80/.813))$$
$$= 617 \text{ therms}$$

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PBTU-V01-060112**

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[233]Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

[234]Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012,which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

[235]Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012,which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

## 6.4.4 Boiler Lockout/Reset Controls

**DESCRIPTION**

This measure relates to improving combustion efficiency by adding controls to non-residential building heating boilers to vary the boiler entering water temperature relative to heating load as a function of the outdoor air temperature to save energy. Energy is saved by increasing the temperature difference between the water temperature entering the boiler in the boiler's heat exchanger and the boiler's burner flame temperature. The flame temperature remains the same while the water temperature leaving the boiler decreases with the decrease in heating load due to an increase in outside air temperature. A lockout temperature is also set to prevent the boiler from turning on when it is above a certain temperature outdoors.

This measure was developed to be applicable to the following program types: RF. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

Natural gas customer adding boiler reset controls capable of resetting the boiler supply water temperature in an inverse linear fashion with outdoor air temperature. Boiler lockout temperatures should be set to 55 F at this time as well, to turn the boiler off when the temperature goes above a certain setpoint.

**DEFINITION OF BASELINE EQUIPMENT**

Existing boiler without boiler reset controls, any size with constant hot water flow.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

**THE LIFE OF THIS MEASURE IS 20 YEARS**[236]

**DEEMED MEASURE COST**

The cost of this measure is $612[237]

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

[236]Resource Solutions Group references the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.
[237]Nexant. Questar DSM Market Characterization Report. August 9, 2006.

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

Therm Savings = Binput * SF * EFLH /(Effpre * 100)

Where:

Binput = Boiler Input Capacity (kBTU)

= custom

SF = Savings factor

= 8%[238] or custom

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[238]Savings factor is the estimate of annual gas consumption that is saved due to adding boiler reset controls.  The Resource Solutions Group uses a boiler tuneup savings value derived from Xcel Energy "DSM Biennial Plan-Technical Assumptions," Colorado.  Focus on Energy uses 8%, citing multiple sources.  Vermont Energy Investment Corporation's boiler reset savings estimates for custom projects further indicate 8% savings estimate is better reflection of actual expected savings.

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EFH        = Equivalent Full Load Hours for heating[239] (hr)

| Building Type | EFLH | | | | |
|---|---|---|---|---|---|
| | Zone 1 (Rockford) | Zone 2 (Chicago) | Zone 3 (Springfield) | Zone 4 (Belleville/ | Zone 5 (Marion) |
| Office - High Rise | 2,746 | 2,768 | 2,656 | 2,155 | 2,420 |
| Office - Mid Rise | 996 | 879 | 824 | 519 | 544 |
| Office - Low Rise | 797 | 666 | 647 | 343 | 329 |
| Convenience | 696 | 550 | 585 | 272 | 297 |
| Healthcare Clinic | 1,118 | 1,036 | 1,029 | 694 | 737 |
| Manufacturing Facility | 1,116 | 1,123 | 904 | 771 | 857 |
| Lodging Hotel/Motel | 2,098 | 2,050 | 1,780 | 1,365 | 1,666 |
| High School | 969 | 807 | 999 | 569 | 674 |
| Hospital | 2,031 | 1,929 | 1,863 | 1,497 | 1,800 |
| Elementary | 970 | 840 | 927 | 524 | 637 |
| Religious Facility | 1,830 | 1,657 | 1,730 | 1,276 | 1,484 |
| Restaurant | 1,496 | 1,379 | 1,291 | 872 | 1,185 |
| Retail - Strip Mall | 1,266 | 1,147 | 1,151 | 732 | 863 |
| Retail - Department Store | 1,065 | 927 | 900 | 578 | 646 |
| College/University | 373 | 404 | 376 | 187 | 187 |
| Warehouse | 416 | 443 | 427 | 226 | 232 |
| Unknown | 1,249 | 1,163 | 1,130 | 786 | 910 |

Effpre    = Boiler Efficiency or custom

= 80%[240] or custom

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**EXAMPLE**

For example, a 800 kBtu boiler at a restaurant in Rockford, IL

$\Delta$Therms = 800 * 0.08 * 1,496 / (0.80 * 100)
= 1197 Therms

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[239]Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types:  office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

[240]Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-BLRC-V01-060112**

## 6.4.5   Condensing Unit Heaters

**DESCRIPTION**

This measure applies to a gas fired condensing unit heater installed in a commercial application.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

In order for this characterization to apply, the efficient equipment is assumed to be a condensing unit heater up to 300 MBH with a Thermal Efficiency > 90% and the heater must be vented, and condensate drained per manufacturer specifications. The unit must be replacing existing natural gas equipment.

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline condition is assumed to be a non-condensing natural gas unit heater at end of life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 12 years[241]

**DEEMED MEASURE COST**

The incremental capital cost for a unit heater is $676[242]

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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[241]DEER 2008
[242]ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 266 Therms.[243]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-CUHT-V01-060112**

## 6.4.6 Electric Chiller

**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. The characterization is not suited for multiple chillers projects or chillers equipped with variable speed drives (VSDs).

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

In order for this characterization to apply, the efficient equipment is assumed to exceed the efficiency requirements of the 2009 International Energy Conservation Code, Table 503.2.3(7)

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements of the2009 International Energy Conservation Code, Table 503.2.3(7).

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 20 years [244].

**DEEMED MEASURE COST**

The incremental capital cost for this measure is provided below.

| Equipment Type | Size Category | Incremental Cost ($/ton)245 |
|---|---|---|
| Air cooled, electrically operated | All capacities | $127/ton[246] |
| Water cooled, electrically operated, positive displacement (reciprocating) | All capacities | $22/ton |
| Water cooled, electrically operated, positive displacement (rotary screw and scroll) | < 150 tons | $128/ton |
| | >= 150 tons and < 300 tons | $70/ton |
| | >= 300 tons | $48/ton |

[244] 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)

[245] 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_080530Rev 1.zip)

[246] Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2006 to IECC 2009 carries the same incremental costs. Values should be verified during evaluation

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C03 - Commercial Cooling

**COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [247]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [248]

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$\Delta kWH$ = TONS * ((12/IPLVbase) – (12/IPLVee)) * EFLH

Where:

TONS = chiller nominal cooling capacity in tons (note: 1 ton = 12,000 Btu/h)

= Actual installed

12 = conversion factor to express Integrated Part Load Value (IPLV) EER in terms of kW per ton

IPLVbase = efficiency of baseline equipment expressed as Integrated Part Load Value EER. Dependent on chiller type. See Baseline Efficiency Values by Chiller Type and Capacity in the Reference Tables section.

IPLVee[249]     = efficiency of high efficiency equipment expressed as Integrated Part Load Value EER [250]

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[247] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[248] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

= Actual installed

EFLH      = equivalent full load hours dependent on location as below:

| System Type[251] | EFLH by Zone[252] | | | | |
|---|---|---|---|---|---|
| | 1 (Rockford) | 2 (Chicago) | 3 (Springfield) | 4 (Belleville) | 5 (Marion) |
| CV reheat, no economizer | 2,723 | 4,206 | 3,341 | 3,872 | 2,734 |
| CV reheat, economizer | 870 | 1,343 | 1,067 | 1,237 | 873 |
| VAV reheat, economizer | 803 | 1,241 | 985 | 1,142 | 806 |

For example, a 100 ton air cooled, with condenser, electrically operated chiller with 3 IPLV, 3 COP of in Rockford with and economizer and CV reheat would save:

$$\Delta kWH = 100 * ((12/12.5) - (12/14)) * 870$$

$$= 8949 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW_{SSP}$      = = $TONS * ((12/PEbase) - (12/PEee)) * CF_{SSP}$

$\Delta kW_{PJM}$      = $TONS * ((12/PEbase) - (12/PEee)) * CF_{PJM}$

Where:

PEbase  = Peak efficiency of baseline equipment expressed as Full Load EER

PEee      = Peak efficiency of high efficiency equipment expressed as Full Load EER

= Actual installed

$CF_{SSP}$      = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3%

$CF_{PJM}$      = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak

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[249]Integrated Part Load Value is 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.
[250]Can determine IPLV from standard testing or looking at engineering specs for design conditions.  Standard data is available from AHRnetI.org.  http://www.ahrinet.org/
[251]CV= Constant Volume, VAV=Variable Air Volume
[252]Cooling EFLHs have been modified from the "Technical Reference Manual (TRM) for Ohio and adjusted by CDD for IL locations. These appear reasonable, but are recommended for further study.

period)

$$= 47.8\%$$

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For example, a 100 ton air cooled, with condenser, electrically operated chiller with 3 IPLV, 3 COP of in Rockford with and economizer and CV reheat would save:

$\Delta kW_{SSP}$        = 100 * ((12/9.562) – (12/10.0)) * .913

               =5.0 kW

---

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**REFERENCE TABLES**

Baseline Efficiency Values by Chiller Type and Capacity[253]

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253  International Energy Conservation Code (IECC)2009

**TABLE 503.2.3(7)**
**WATER CHILLING PACKAGES, EFFICIENCY REQUIREMENTS[a]**

| EQUIPMENT TYPE | SIZE CATEGORY | UNITS | BEFORE 1/1/2010 FULL LOAD | BEFORE 1/1/2010 IPLV | AS OF 1/1/2010[c] PATH A FULL LOAD | AS OF 1/1/2010[c] PATH A IPLV | AS OF 1/1/2010[c] PATH B FULL LOAD | AS OF 1/1/2010[c] PATH B IPLV | TEST PROCEDURE[b] |
|---|---|---|---|---|---|---|---|---|---|
| Air-cooled chillers | < 150 tons | EER | ≥ 9.562 | ≥ 10.416 | ≥ 9.562 | ≥ 12.500 | NA[d] | NA[d] | AHRI 550/590 |
| | ≥ 150 tons | EER | | | ≥ 9.562 | ≥ 12.750 | NA[d] | NA[d] | |
| Air cooled without condenser, electrical operated | All capacities | EER | ≥ 10.586 | ≥ 11.782 | Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements | | | | |
| Water cooled, electrically operated, reciprocating | All capacities | kW/ton | ≤ 0.837 | ≤ 0.696 | Reciprocating units must comply with water cooled positive displacement efficiency requirements | | | | |
| Water cooled, electrically operated, positive displacement | < 75 tons | kW/ton | | | ≤ 0.780 | ≤ 0.630 | ≤ 0.800 | ≤ 0.600 | |
| | ≥ 75 tons and < 150 tons | kW/ton | ≤ 0.790 | ≤ 0.676 | ≤ 0.775 | ≤ 0.615 | ≤ 0.790 | ≤ 0.586 | |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.717 | ≤ 0.627 | ≤ 0.680 | ≤ 0.580 | ≤ 0.718 | ≤ 0.540 | |
| | ≥ 300 tons | kW/ton | ≤ 0.639 | ≤ 0.571 | ≤ 0.620 | ≤ 0.540 | ≤ 0.639 | ≤ 0.490 | |
| Water cooled, electrically operated, centrifugal | < 150 tons | kW/ton | ≤ 0.703 | ≤ 0.669 | ≤ 0.634 | ≤ 0.596 | ≤ 0.639 | ≤ 0.450 | |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.634 | ≤ 0.596 | | | | | |
| | ≥ 300 tons and < 600 tons | kW/ton | ≤ 0.576 | ≤ 0.549 | ≤ 0.576 | ≤ 0.549 | ≤ 0.600 | ≤ 0.400 | |
| | ≥ 600 tons | kW/ton | ≤ 0.576 | ≤ 0.549 | ≤ 0.570 | ≤ 0.539 | ≤ 0.590 | ≤ 0.400 | |
| Air cooled, absorption single effect | All capacities | COP | ≥ 0.600 | NR[e] | ≥ 0.600 | NR[e] | NA[d] | NA[d] | AHRI 560 |
| Water-cooled, absorption single effect | All capacities | COP | ≥ 0.700 | NR[e] | ≥ 0.700 | NR[e] | NA[d] | NA[d] | |
| Absorption double effect, indirect-fired | All capacities | COP | ≥ 1.000 | ≥ 1.050 | ≥ 1.000 | ≥ 1.050 | NA[d] | NA[d] | |
| Absorption double effect, direct fired | All capacities | COP | ≥ 1.000 | ≥ 1.000 | ≥ 1.000 | ≥ 1.000 | NA[d] | NA[d] | |

For SI:   1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W.

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 40°F.
b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or B.
d. NA means that this requirement is not applicable and cannot be used for compliance.
e. NR means that there are no minimum requirements for this category.

**MEASURE CODE: CI-HVC-CHIL-V01-060112**

## 6.4.7   ENERGY STAR and CEE Tier 1 Room Air Conditioner

**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:[254]

| Product Class (Btu/H) | Federal Standard EER, with louvered sides | Federal Standard EER, without louvered sides | ENERGY STAR EER, with louvered sides | ENERGY STAR EER, without louvered sides | CEE TIER 1 EER |
|---|---|---|---|---|---|
| < 8,000 | 9.7 | 9 | 10.7 | 9.9 | 11.2 |
| 8,000 to 13,999 | 9.8 | 8.5 | 10.8 | 9.4 | 11.3 |
| 14,000 to 19,999 | 9.7 | 8.5 | 10.7 | 9.4 | 11.2 |
| >= 20,000 | 8.5 | 8.5 | 9.4 | 9.4 | 9.8 |

| Casement | Federal Standard (EER) | ENERGY STAR (EER) |
|---|---|---|
| Casement-only | 8.7 | 9.6 |
| Casement-slider | 9.5 | 10.5 |

| Reverse Cycle - Product Class (Btu/H) | Federal Standard EER, with louvered sides | Federal Standard EER, without louvered sides | ENERGY STAR EER, with louvered sides | ENERGY STAR EER, without louvered sides |
|---|---|---|---|---|
| < 14,000 | N/A | 8.5 | N/A | 9.4 |
| >= 14,000 | N/A | 8 | N/A | 8.8 |
| < 20,000 | 9 | N/A | 9.9 | N/A |
| >= 20,000 | 8.5 | N/A | 9.4 | N/A |

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

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[254]http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac and http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf

Side louvers that extend from a room air conditioner model in order to position the unit in a window. A model without louvered sides is placed in a built-in wall sleeveand are commonly referred to as "through-the-wall" or "built-in" models.

Casement-only refers to a room air conditioner designed for mounting in a casement window of a specific size. Casement-slider refers to a room air conditioner with an encased assembly designed for mounting in a sliding or casement window of a specific size.

Reverse cycle refers to the heating function found in certain room air conditioner models.

http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the new room air conditioning unit must meet the ENERGY STAR 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 LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years.[255]

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.[256]

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [257]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [258]

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[255] Energy Star Room Air Conditioner Savings Calculator,
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=AC
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf
[256] Based on field study conducted by Efficiency Vermont
[257]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

$$\Delta kWh = (FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$$

Where:

$FLH_{RoomAC}$ = Full Load Hours of room air conditioning unit

= dependent on location:[259]

| Zone | $FLH_{RoomAC}$ |
|---|---|
| 1 (Rockford) | 253 |
| 2-(Chicago) | 254 |
| 3 (Springfield) | 310 |
| 4-(Belleville) | 391 |
| 5-(Marion) | 254 |

Btu/H = Size of unit

= Actual. If unknown assume 8500 BTU/hour [260]

EERbase = Efficiency of baseline unit

= As provided in tables above

EERee = Efficiency of ENERGY STAR or CEE Tier 1 unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

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[258]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[259]Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided 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) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio has been applied to the FLH from the unitary and split system air conditioning measure.

[260]Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

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> For example for an 8,500 BTU/H capacity ENERGY STAR unit, with louvered sides, in Rockford:
>
> $\Delta kWH_{ENERGY\ STAR}$ = (253 * 8500 * (1/9.8 – 1/10.8)) / 1000
>
> = 20.3 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW = Btu/H * ((1/EERbase - 1/EERee))/1000 * CF$

Where:

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour) = 91.3% [261]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [262]

Other variable as defined above

For example for an 8,500 BTU/H capacity ENERGY STAR unit, with louvered sides, in Rockford during system peak

$\Delta kW_{ENERGY\ STAR}$ = (8500 * (1/9.8 – 1/10.8)) / 1000 * 0.913

= 0.073 kW

**FOSSIL FUEL SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-ESRA-V01-060112**

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[261] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[262] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

## 6.4.8   Guest Room Energy Management (PTAC & PTHP)

**DESCRIPTION**

This measure applied to the installation of a temperature setback and lighting control system for individual guest rooms. The savings are achieved based on Guest Room Energy Management's (GREM's) ability to automatically adjust the guest room's set temperatures and control the HVAC unit for various occupancy modes.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

Guest room temperature set point must be controlled by automatic occupancy detectors or keycard that indicates the occupancy status of the room. During unoccupied periods the default setting for controlled units differs by at least 5 degrees from the operating set point. Theoretically, the control system may also be tied into other electric loads, such as lighting and plug loads to shut them off when occupancy is not sensed.  This measure bases savings on improved HVAC controls.  If system is connected to lighting and plug loads, additional savings would be realized. The incentive is per guestroom controlled, rather than per sensor, for multi-room suites. Replacement or upgrades of existing occupancy-based controls are not eligible for an incentive.

**DEFINITION OF BASELINE EQUIPMENT**

Manual Heating/Cooling Temperature Setpoint and Fan On/Off/Auto Thermostat

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life for GREM is 15 years [263].

**DEEMED MEASURE COST**

$260/unit

The IMC documented for this measure is $260 per room HVAC controller, which is the cost difference between a non-programmable thermostat and a GREM[264].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C03 - Commercial Cooling

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[263]DEER 2008 value for energy management systems
[264]This value was extracted from Smart Ideas projects in PY1 and PY2.

COINCIDENCE FACTOR[265]

The coincidence factor for this measure is 0.67

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**Algorithm**

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CALCULATION OF SAVINGS

Below are the annual kWh savings per installed EMS for different sizes and types of HVAC units. The savings are achieved based on GREM's ability to automatically adjust the guest room's set temperatures and control the HVAC unit to maintain set temperatures for various occupancy modes. These values are from the Michigan savings database using Michigan's 574 annual CDD and 6,676 annual HDD, which are conservative when compared to 857 CDD and 6,418 HDD in Zon2 1 (Chicago).

ELECTRIC ENERGY SAVINGS

**Measure Savings for GREM**

| Cooling Type | Cooling kWh | | Heating (kWh & Therms) | | Total kWh | |
|---|---|---|---|---|---|---|
| | 3/4 ton | 1 ton | 3/4 ton | 1 ton | 3/4 ton | 1 ton |
| PTAC | 208 | 287 | 1,234 kWh | 1,645 kWh | 1,441 | 1,932 |
| PTHP | 181 | 263 | 721 kWh | 988 kWh | 902 | 1,251 |
| FCU with Gas Heat/Elec Cool | 407 | 542 | 53 Therms | 70 Therms | 407 | 542 |

On average, the annual kWh saving for a 0.75 ton and 1 ton HVAC unit with electric cooling and electric heating is 1,117 kWh per room. For non-electric heating, it is assumed the savings are approximately one third at 334 kWh per room. The average between 0.75 and 1 tons is used for a conservative estimate. However, it is assumed that most PTAC units in hotel rooms are sized to 1 ton.

**Measure Savings Analysis**

Savings estimate shall be verified using an eQuest model. The Michigan work paper assumes a 30% savings with the GREM. The model outputs will be validated by actual monitored projects, as they become available. Once the model is calibrated, its outputs will be used to update the work paper. The inputs for simulating average occupancy and setback temperatures are as follows (90% occupancy rate is assumed):

      **Base case:** 72°F all the time

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[265]KEMA

**Proposed case**:

| Cooling Type | Cooling, °F | | Heating, °F | |
|---|---|---|---|---|
| | Occupied Rooms | Unoccupied Rooms | Occupied Rooms | Unoccupied Rooms |
| 6pm-11pm | 72 | 85 | 72 | 65 |
| 11pm- 7am | 78 | 85 | 65 | 65 |
| 7am- 9am | 72 | 85 | 72 | 65 |
| 9am- 6pm | 78 | 85 | 65 | 65 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

The coincident kW impacts for this measure have not been sufficiently studied or modeled to provide a confident estimate. In the meantime the following kW impacts are estimated for systems that control cooling operation.

kW Savings per ton = (12/HVAC EER) x average on peak uncontrolled load factor of 50% (estimated from anecdotal observations by KEMA for NV Energy) x estimated cycling reduction of 30% (estimated by KEMA from empirical observations and logging from manufacturers for NV Energy)

$$kW = (12/8.344) \times 0.5 \times 0.3 = 1.25 \text{ kW per ton or room}$$

where,

HVAC EER = is based on a 1 ton unit at code baseline efficiency of PTAC,

defined as EER = 10.9 – (0.213 x 12000 btu/hr/1000) = 8.344

In addition, a coincident factor for cooling needs to be included to consider that not all room PTAC units are operating at the same. It is estimated as 0.67 (Ref: Pennsylvania Technical Resource Manual (12/23/09 version) for HVAC Measures, Table 6.17 p 55) This factor will be used pending further study.

Coincident kW Savings = 1.25 x 0.67 = 0.84 kW per unit-ton or per room

**NATURAL GAS ENERGY SAVINGS**

| Heating | Heating (Therms) | |
|---|---|---|
| | 3/4 ton | 1 ton |
| FCU with Gas Heat/Elec Cool | 53 Therms | 70 Therms |

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-GREM-V01-060112**

## 6.4.9   Heat Pump Systems

### DESCRIPTION

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

This measure was developed to be applicable to the following program types: TOS NC., If applied to other program types, the measure savings should be verified.

### 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 the International Energy Conservation Code (IECC) 2006, Table 503.2.3(2).

### 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 the International Energy Conservation Code (IECC) 2006, Table 503.2.3(2). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[266]

### DEEMED MEASURE COST

For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.[267] The incremental cost for all other equipment types should be determined on a site-specific basis

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

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[266]Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

[267]Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [268]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [269]

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For units with cooling capacities less than 65 kBtu/h:

$\Delta kWh$ = Annual kWh Savings$_{cool}$ + Annual kWh Savings$_{heat}$

Annual kWh Savings$_{cool}$ = (kBtu/h$_{cool}$) * [(1/SEERbase) – (1/SEERee)] * EFLH$_{cool}$

Annual kWh Savings$_{heat}$ = (kBtu/h$_{cool}$) * [(1/HSPFbase) – (1/HSPFee)] * EFLH$_{heat}$

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

$\Delta kWh$ = Annual kWh Savings$_{cool}$ + Annual kWh Savings$_{heat}$

Annual kWh Savings$_{cool}$ = (kBtu/h$_{cool}$) * [(1/EERbase) – (1/EERee)] * EFLH$_{cool}$

Annual kWh Savings$_{heat}$ = (kBtu/h$_{heat}$)/3.412 * [(1/COPbase) – (1/COPee)] * 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

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[268]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[269]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values. [270].

**TABLE 503.2.3(2)**
**UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS**

| EQUIPMENT TYPE | SIZE CATEGORY | SUBCATEGORY OR RATING CONDITION | MINIMUM EFFICIENCY[b] | TEST PROCEDURE[a] |
|---|---|---|---|---|
| Air cooled, (Cooling mode) | < 65,000 Btu/h[d] | Split system | 13.0 SEER | AHRI 210/240 |
| | | Single package | 13.0 SEER | |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Split system and single package | 10.1 EER[c] (before Jan 1, 2010) 11.0 EER[c] (as of Jan 1, 2010) | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Split system and single package | 9.3 EER[c] (before Jan 1, 2010) 10.6 EER[c] (as of Jan 1, 2010) | AHRI 340/360 |
| | ≥ 240,000 Btu/h | Split system and single package | 9.0 EER[c] 9.2 IPLV[c] (before Jan 1, 2010) 9.5 EER[c] 9.2 IPLV[c] (as of Jan 1, 2010) | |
| Through-the-Wall (Air cooled, cooling mode) | < 30,000 Btu/h[d] | Split system | 10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010) | AHRI 210/240 |
| | | Single package | 10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010) | |
| Water Source (Cooling mode) | < 17,000 Btu/h | 86°F entering water | 11.2 EER | AHRI/ASHRAE 13256-1 |
| | ≥ 17,000 Btu/h and < 135,000 Btu/h | 86°F entering water | 12.0 EER | AHRIASHRAE 13256-1 |
| Groundwater Source (Cooling mode) | < 135,000 Btu/h | 59°F entering water | 16.2 EER | AHRI/ASHRAE 13256-1 |
| Ground source (Cooling mode) | < 135,000 Btu/h | 77°F entering water | 13.4 EER | AHRI/ASHRAE 13256-1 |
| Air cooled (Heating mode) | < 65,000 Btu/h[d] (Cooling capacity) | Split system | 7.7 HSPF | AHRI 210/240 |
| | | Single package | 7.7 HSPF | |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h (Cooling capacity) | 47°F db/43°F wb Outdoor air | 3.2 COP (before Jan 1, 2010) 3.3 COP (as of Jan 1, 2010) | |
| | ≥ 135,000 Btu/h (Cooling capacity) | 47°F db/43°F wb Outdoor air | 3.1 COP (before Jan 1, 2010) 3.2 COP (as of Jan 1, 2010) | AHRI 340/360 |

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[270] International Energy Conservation Code (IECC) 2009

TABLE 503.2.3(2)—continued
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

| EQUIPMENT TYPE | SIZE CATEGORY | SUBCATEGORY OR RATING CONDITION | MINIMUM EFFICIENCY[b] | TEST PROCEDURE[a] |
|---|---|---|---|---|
| Through-the-wall (Air cooled, heating mode) | < 30,000 Btu/h | Split System | 7.1 HSPE (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010) | AHRI 210/240 |
| | | Single package | 7.0 HSPF (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010) | |
| Water source (Heating mode) | < 135,000 Btu/h (Cooling capacity) | 68°F entering water | 4.2 COP | AHRI/ASHRAE 13256-1 |
| Groundwater source (Heating mode) | < 135,000 Btu/h (Cooling capacity) | 50°F entering water | 3.6 COP | AHRI/ASHRAE 13256-1 |
| Ground source (Heating mode) | < 135,000 Btu/h (Cooling capacity) | 32°F entering water | 3.1 COP | AHRI/ASHRAE 13256-1 |

For SI:   °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W.
db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.
a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
d. Single-phase air-cooled heat pumps < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER and HSPF values are those set by NAECA.

SEERee   = 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:

| Zone | Equivalent Full Load Hours Cooling (EFLHl)271 | Equivalent Full Load heating Cooling (EFLH) |
|---|---|---|
| 1 (Rockford) | 816 | 1153 |
| 2 (Chicago) | 819 | 1069 |
| 3 (Springfield) | 1001 | 885 |
| 4 (Belleville) | 1261 | 621 |
| 5 (Marion) | 819 | 623 |

HSPFbase        = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPFee        = Heating Seasonal Performance Factor of the energy efficient equipment.

= Actual installed

---

[271]Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM.  Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models.  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. The Ohio values were adjusted base on CCD and HDD for IL locations. Further study recommended for IL specific building types.

$EFLH_{heat}$ = heating mode equivalent full load hours; see table above for default values.

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2006 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

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

= Actual installed

$kBtu/h_{heat}$ = capacity of the heating equipment in kBtu per hour.

= Actual installed

3.412 = Btu per Wh.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

Annual kWh Savings$_{cool}$ = (kBtu/h$_{cool}$) * [(1/SEERbase) – (1/SEERee)] * EFLH$_{cool}$

Annual kWh Savings$_{heat}$ = (kBtu/h$_{heat}$) * [(1/HSPFbase) – (1/HSPFee)] * EFLH$_{heat}$

---

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

= [(60) * [(1/13) – (1/14)] * 816] + [(60)/3.412 * [(1/7.7) – (1/9)] * 1153]

= 649 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = (kBtu/h$_{cool}$) * [(1/EERbase) – (1/EERee)] *CF

Where CF value is chosen between:

CF$_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [272]

CF$_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

---

[272]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

= 47.8%[273]

---

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

$$\Delta kW = [(60) * [(1/13) - (1/14)] *.913$$

$$= 0.3$$

---

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-HPSY-V01-060112**

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[273]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

## 6.4.10  High Efficiency Boiler[274]

**DESCRIPTION**

To qualify for this measure the installed equipment must be replacement of an existing boiler at the end of its service life, in a commercial space 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.

This measure was developed to be applicable to the following program types: TOS, RF. If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be a boiler used 80% or more for space heating, not process, and boiler AFUE, TE (thermal efficiency), or Ec (combustion efficiency) rating must be rated greater than or equal to 85%.

**DEFINITION OF BASELINE EQUIPMENT**

dependent on when the unit is installed and whether the unit is hot water or steam. The baseline efficiency source is the Energy Independence and Security Act of 2007 with technical amendments from Federal Register, volume 73, Number 145, Monday, July 28, 2008 for boilers <300,000 Btu/h and is Final Rule, Federal Register, volume 74, Number 139, Wednesday, July 22, 2009 for boiler ≥300,000 Btu/h..

Hot water boiler baseline:

| Year | AFUE or TE |
|---|---|
| Hot Water <300,000 Btu/h < Sept 1, 2012 | 80% AFUE |
| Hot Water <300,000 Btu/h  ≥ Sept 1, 2012 | 82% AFUE |
| Hot Water  ≥300,000 & ≤2,500,000 Btu/h | 80% TE |
| Hot Water  >2,500,000 Btu/h | 82% Ec |

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[274]High Impact Measure

Steam boiler baseline:

| Year | AFUE or TE |
|---|---|
| Steam <300,000 Btu/h < Sept 1, 2012 | 75% AFUE |
| Steam <300,000 Btu/h ≥Sept 1, 2012 | 80% AFUE |
| Steam - all except natural draft ≥300,000 & ≤2,500,000 Btu/h | 79% TE |
| Steam - natural draft ≥300,000 & ≤2,500,000 Btu/h | 77% TE |
| Steam - all except natural draft >2,500,000 Btu/h | 79% TE |
| Steam - natural draft >2,500,000 Btu/h | 77% TE |

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 20 years[275]

**DEEMED MEASURE COST**

The incremental capital cost for this measure depends on efficiency as listed below[276]

| Measure Tier | Incr. Cost, per unit |
|---|---|
| ENERGY STAR® Minimum | $1,470 |
| AFUE 90% | $2,400 |
| AFUE 95% | $3,370 |
| AFUE ≥ 96% | $4,340 |
| Boilers > 300,000 Btu/h with TE (thermal efficiency) rating | Custom |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

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[275] The Technical support documents for federal residential appliance standards: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf Note that this value is below the 20 years used by CA's DEER and the range of 20-40 year estimate made by the Consortium for Energy Efficiency in 2010

[276] Average of low and high incremental cost based on Nicor program data for non-condensing and condensing boilers. Nicor Gas Energy Efficiency Plan 2011 - 2014, May 27, 2011 $1,470 for ≤ 300,000 Btu/hr for non-condensing hydronic boilers >85% AFUE & $3,365 for condensing boilers > 90% AFUE.  The exception is  $4,340 for AFUE ≥ 96% AFUE which was obtained from extrapolation above the size range that Nicor Gas Energy Efficiency Plan provided for incremental cost.

**COINCIDENCE FACTOR**

N/A

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**Algorithm**

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**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$$\Delta Therms \qquad EFLH * Capacity * (1/AFUEbase) - 1/AFUEeff) / 100,000$$

Where:

EFH  = Equivalent Full Load Hours for heating[277] (hr)

| Building Type | EFLH | | | | |
|---|---|---|---|---|---|
| | Zone 1 (Rockford) | Zone 2 (Chicago) | Zone 3 (Springfield) | Zone 4 (Belleville/ | Zone 5 (Marion) |
| Office - High Rise | 2,746 | 2,768 | 2,656 | 2,155 | 2,420 |
| Office - Mid Rise | 996 | 879 | 824 | 519 | 544 |
| Office - Low Rise | 797 | 666 | 647 | 343 | 329 |
| Convenience | 696 | 550 | 585 | 272 | 297 |
| Healthcare Clinic | 1,118 | 1,036 | 1,029 | 694 | 737 |
| Manufacturing Facility | 1,116 | 1,123 | 904 | 771 | 857 |
| Lodging Hotel/Motel | 2,098 | 2,050 | 1,780 | 1,365 | 1,666 |
| High School | 969 | 807 | 999 | 569 | 674 |
| Hospital | 2,031 | 1,929 | 1,863 | 1,497 | 1,800 |
| Elementary | 970 | 840 | 927 | 524 | 637 |
| Religious Facility | 1,830 | 1,657 | 1,730 | 1,276 | 1,484 |
| Restaurant | 1,496 | 1,379 | 1,291 | 872 | 1,185 |
| Retail - Strip Mall | 1,266 | 1,147 | 1,151 | 732 | 863 |
| Retail - Department Store | 1,065 | 927 | 900 | 578 | 646 |
| College/University | 373 | 404 | 376 | 187 | 187 |
| Warehouse | 416 | 443 | 427 | 226 | 232 |
| Unknown | 1,249 | 1,163 | 1,130 | 786 | 910 |

Capacity  = Nominal Heating Capacity Boiler Size (btuh)

= custom Boiler input capacity in Btu/hr

AFUE(base)  = Baseline Furnace Annual Fuel Utilization Efficiency Rating, dependant on year and boiler type as listed below:

| Year | AFUE |
|---|---|
| Hot Water < Sept 1, 2012 | 80% |
| Hot Water ≥ Sept 1, 2012 | 82% |
| Steam < Sept 1, 2012 | 75% |
| Steam ≥ Sept 1, 2012 | 80% |

---

[277]Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types:  office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

AFUE(eff)= Efficent Furnace Annual Fuel Utilization Efficiency Rating = ddependent on tier as listed below for lookup table or custom

| Measure Type | Actual AFUE |
|---|---|
| ENERGY STAR® Minimum | 85% |
| AFUE 90% | 90% |
| AFUE 95% | 95% |
| AFUE ≥ 96% | ≥ 96% |
| Custom | Value to one significant digit i.e. 95.7% |

**EXAMPLE**

For example, a 150,000 btu/hr water boiler meeting AFUE 90% in Rockford at a high rise office building , in the year 2012

ΔTherms　　　= 2,746* 150,000  * (1/.80 - 1/.90) / 100,000 Btu/Therm
　　　　　　　= 572 Therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-BOIL-V01-060112**

## 6.4.11  High Efficiency Furnace[278]

### DESCRIPTION

This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace in a commercial or industrial space.  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

This measure was developed to be applicable to the following program types: TOS, RF.  If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas fired furnace with a minimum Annual Fuel Utilization Efficiency (AFUE) rating of 92% and input rating of less than 225,000 Btu/hr.

### DEFINITION OF BASELINE EQUIPMENT

Though the current federal minimum AFUE rating is 78%, based upon market sales data, the baseline efficiency for this characterization is assumed to be 80% up until when the federal minimum efficiency standards are raised to AFUE 90% in 2013.

### DEFINITION OF MEASURE LIFE

The expected measure life is assumed to be 16.5 years[279]

### DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below[280]

| Measure Tier | Incr. Cost, per unit |
|---|---|
| CEE Tier 2 - 92% | $477 |
| CEE Tier 2 - 93% | $567 |
| CEE Tier 3 - 94% | $657 |
| CEE Tier 3 - 95% | $754 |
| ≥ 96% AFUE | $851 |

---

[278] High Impact Measure
[279] Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.
[280] Appliance Standards Technical Support Documents
(http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html )

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Brushless DC motor or Electronically commutated motor (ECM)
= 418 kWh[281]

Cooling Savings = Brushless DC motor or electronically commutated motor (ECM) savings during cooling season

If air conditioning = 263 kWh

If no air conditioning = 175 kWh

If unknown (weighted average)= 241 kWh[282]

Shoulder Season Savings = Brushless DC motor or electronically commutated motor (ECM) savings during shoulder seasons

= 51 kWh

---

[281]To estimate heating, cooling and shoulder season savings for Illinois, VEIC adapted results from a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin. This study included effects of behavior change based on the efficiency of new motor greatly increasing the amount of people that run the fan continuously. The savings from the Wisconsin study were adjusted to account for different run hour assumptions (average values used) for Illinois. See: FOE to IL Blower Savings.xlsx.

[282]The weighted average value is based on assumption that 75% of homes installing BPM furnace blower motors have Central AC. 66% of IL housing units have CAC and 66% have gas furnaces. It is logical these two groups overlap to a large extent (like the 95% in the FOE study above).

---

---

**EXAMPLE**

For example, a blower motor in a building where air conditioning presence is unknown:
    ΔkWh    = Heating Savings + Cooling Savings + Shoulder Season Savings
            = 418 +251 + 51
            = 721 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = (ΔkWh/(HOURSyear *DaysYear)) * CF

Where:

HOURSyear = Actual hours per year if known, otherwise use hours from Table below for building type.

| Building Type | Pumps and fans (h/yr) |
|---|---|
| College/University | 4216 |
| Grocery | 5840 |
| Heavy Industry | 3585 |
| Hotel/Motel | 6872 |
| Light Industry | 2465 |
| Medical | 6871 |
| Office | 1766 |
| Restaurant | 4654 |
| Retail/Service | 3438 |
| School(K-12) | 2203 |
| Warehouse | 3222 |
| Average=Miscellaneous | 4103 |

CF    =Summer Peak Coincidence Factor for measure is provided below for different building types[283]:

| Location | CF |
|---|---|
| Restaurant | 0.80 |
| Office | 0.66 |
| School (K-12) | 0.22 |
| College/University | 0.56 |
| Medical | 0.75 |

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[283]Based on DEER 2008 values

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**EXAMPLE**

For example, a 150,000 btu/hr furnace for an office building:

$\Delta kW$ = (721 kWh/(12 h/d *365.25 d/yr))  *  0.68 = 0.11 kW

---

**NATURAL GAS ENERGY SAVINGS**

$\Delta Therms$ = EFLH * Capacity * (1/AFUE(base) - 1/AFUE(eff)) / 100,000 Btu/Therm

Where:

EFH = Equivalent Full Load Hours for heating[284] (hr)

| Building Type | EFLH | | | | |
|---|---|---|---|---|---|
| | Zone 1 (Rockford) | Zone 2 (Chicago) | Zone 3 (Springfield) | Zone 4 (Belleville/ | Zone 5 (Marion) |
| Office - High Rise | 2,746 | 2,768 | 2,656 | 2,155 | 2,420 |
| Office - Mid Rise | 996 | 879 | 824 | 519 | 544 |
| Office - Low Rise | 797 | 666 | 647 | 343 | 329 |
| Convenience | 696 | 550 | 585 | 272 | 297 |
| Healthcare Clinic | 1,118 | 1,036 | 1,029 | 694 | 737 |
| Manufacturing Facility | 1,116 | 1,123 | 904 | 771 | 857 |
| Lodging Hotel/Motel | 2,098 | 2,050 | 1,780 | 1,365 | 1,666 |
| High School | 969 | 807 | 999 | 569 | 674 |
| Hospital | 2,031 | 1,929 | 1,863 | 1,497 | 1,800 |
| Elementary | 970 | 840 | 927 | 524 | 637 |
| Religious Facility | 1,830 | 1,657 | 1,730 | 1,276 | 1,484 |
| Restaurant | 1,496 | 1,379 | 1,291 | 872 | 1,185 |
| Retail - Strip Mall | 1,266 | 1,147 | 1,151 | 732 | 863 |
| Retail - Department Store | 1,065 | 927 | 900 | 578 | 646 |
| College/University | 373 | 404 | 376 | 187 | 187 |
| Warehouse | 416 | 443 | 427 | 226 | 232 |
| Unknown | 1,249 | 1,163 | 1,130 | 786 | 910 |

---

[284]Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types:  office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

---

Capacity = Nominal Heating Capacity Furnace Size (btuh)

= custom Furnace input capacity in Btu/hr or if unknown 150,000

AFUE(base)= Baseline Furnace Annual Fuel Utilization Efficiency Rating, dependant on year as listed below:

| Year | AFUE |
|------|------|
| 2012 | 80% |
| 2013- | 90% |

AFUE(eff)= Efficent Furnace Annual Fuel Utilization Efficiency Rating = dependent on tier as listed below for lookup table or custom

| Measure Type | Actual AFUE |
|--------------|-------------|
| AFUE 92% - 94.9% | 93.5%% |
| AFUE≥95% | 96% |
| Custom | Value to one significant digit i.e.  95.7% |

---

**EXAMPLE**

For example, a 150,000 btu/hr 92% efficient furnace at a high rise office building in Rockford, in the year 2012

$$\Delta\text{Therms} = 2{,}746 * 150{,}000 * (1/80\% - 1/92\%) / 100{,}000 \text{ Btu/Therm}$$
$$= 672 \text{ Therms}$$

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-FRNC-V01-060112**

## 6.4.12  Infrared Heaters (all sizes), Low Intensity

### DESCRIPTION

This measure applies to natural gas fired low-intensity infrared heaters with an electric ignition that use non-conditioned air for combustion

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas heater with an electric ignition that uses non-conditioned air for combustion

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a standard natural gas fired heater warm air heater.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[285]

### DEEMED MEASURE COST

The incremental capital cost for this measure is $1716[286]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

N/A

### COINCIDENCE FACTOR

N/A

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[285]ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor were used. Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011
[286]Ibid.

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 451 Therms[287]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-IRHT-V01-060112**

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[287]Nicor Gas Energy Efficiency Plan 2011-2014.  Revised Plan Filed Pursuant to Order Docket 10-0562,  May 27, 2011.These deemed values should be compared to PY evaluation and revised as necessary.

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## 6.4.13  Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)

### DESCRIPTION

A PTAC is a packaged terminal air conditioner that cools and sometimes provides heat through an electric resistance heater (heat strip). A PTHP is a packaged terminal heat pump. A PTHP uses its compressor year round to heat or cool. In warm weather, it efficiently captures heat from inside your building and pumps it outside for cooling. In cool weather, it captures heat from outdoor air and pumps it into your home, adding heat from electric heat strips as necessary to provide heat.

This measure was developed to be applicable to the following program types: TOS NC. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be PTACs or PTHPs that exceed baseline efficiencies replacing existing equipment at the end of its useful life.

### DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline conditions must be met as listed in the reference table.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years. [288]

### DEEMED MEASURE COST

The incremental capital cost for this equipment is estimated to be $84/ton.[289]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C03 - Commercial Cooling

### COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

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[288]Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007

[289]DEER 2008 This assumes that baseline shift from IECC 2006 to IECC 2009 carries the same incremental costs. Values should be verified during evaluation

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [290]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [291]

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Electric savings for PTACs and PTHPs should be calculated using the following algorithms

**ENERGY SAVINGS**

For units with cooling capacities less than 65 kBtu/h:

$\Delta kWh$ = Annual kWh Savings$_{cool}$ + Annual kWh Savings$_{heat}$

Annual kWh Savings$_{cool}$ = (kBtu/h$_{cool}$) * [(1/SEERbase) – (1/SEERee)] * EFLH$_{cool}$

Annual kWh Savings$_{heat}$ = (kBtu/h$_{cool}$) * [(1/HSPFbase) – (1/HSPFee)] * EFLH$_{heat}$

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

$\Delta kWh$ = Annual kWh Savings$_{cool}$ + Annual kWh Savings$_{heat}$

Annual kWh Savings$_{cool}$ = (kBtu/h$_{cool}$) * [(1/EERbase) – (1/EERee)] * EFLH$_{cool}$

Annual kWh Savings$_{heat}$ = (kBtu/h$_{heat}$)/3.412 * [(1/COPbase) – (1/COPee)] * 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

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[290]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[291]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for baseline values[292].

TABLE 503.2.3(3)
PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS

| EQUIPMENT TYPE | SIZE CATEGORY (INPUT) | SUBCATEGORY OR RATING CONDITION | MINIMUM EFFICIENCY[b] | TEST PROCEDURE[a] |
|---|---|---|---|---|
| PTAC (Cooling mode) New construction | All capacities | 95°F db outdoor air | 12.5 - (0.213 · Cap/1000) EER | |
| PTAC (Cooling mode) Replacements[c] | All capacities | 95°F db outdoor air | 10.9 - (0.213 · Cap/1000) EER | |
| PTHP (Cooling mode) New construction | All capacities | 95°F db outdoor air | 12.3 - (0.213 · Cap/1000) EER | AHRI 310/380 |
| PTHP (Cooling mode) Replacements[c] | All capacities | 95°F db outdoor air | 10.8 - (0.213 · Cap/1000) EER | |
| PTHP (Heating mode) New construction | All capacities | — | 3.2 - (0.026 · Cap/1000) COP | |
| PTHP (Heating mode) Replacements[c] | All capacities | — | 2.9 - (0.026 · Cap/1000) COP | |

For SI:   °C - [(°F) - 32]/1.8, 1 British thermal unit per hour - 0.2931 W.
db = dry-bulb temperature, °F.
wb = wet-bulb temperature, °F.
a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
c. Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) high and less than 42 inches (1067 mm) wide.

SEERee = 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:

| Zone | Equivalent Full Load Hours Cooling (EFLHI)[293] | Equivalent Full Load heating Cooling (EFLH) |
|---|---|---|
| 1 (Rockford) | 816 | 1153 |
| 2 (Chicago) | 819 | 1069 |
| 3 (Springfield) | 1001 | 885 |
| 4 (Belleville) | 1261 | 621 |
| 5 (Marion) | 819 | 623 |

---

[292] International Energy Conservation Code (IECC) 2009
[293] Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM.  Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models.  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. The Ohio values were adjusted base on CCD and HDD for IL locations. Further study recommended for IL specific building types.

HSPFbase = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPFee = Heating Seasonal Performance Factor of the energy efficient equipment.

= Actual installed

$EFLH_{heat}$ = heating mode equivalent full load hours; see table above for default values.

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2009 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

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

= Actual installed

$kBtu/h_{heat}$ = capacity of the heating equipment in kBtu per hour.

= Actual installed

3.412 = Btu per Wh.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

---

For example a 5 ton replacement cooling unit with no heating with an efficient SEER of 20 saves

= [(60) * [(1/19.456) – (1/20)] * 816

= 68 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW$ = (kBtu/$h_{cool}$) * [(1/EERbase) – (1/EERee)] *CF

Depending on situation:

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [294]

$CF_{PJM}$     = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [295]

---

For example a 5 ton replacement cooling unit with no heating with an efficient EER of 20 saves

ΔkW         = (60) * [(1/19.456) – (1/20)] *0.913

---

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PTAC-V01-060112**

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[294]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[295] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

## 6.4.14 Single-Package and Split System Unitary Air Conditioners

**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.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

**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 the International Energy Conservation Code (IECC) 2009, Table 503.2.3(1).

**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 the International Energy Conservation Code (IECC) 2006, Table 503.2.3(1). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 15 years.[296]

**DEEMED MEASURE COST**

The incremental capital cost for this measure is assumed to be $100 per ton.[297]

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C03 - Commercial Cooling

**COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to

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[296]Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

[297]Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2006 to IECC 2009 carries the same incremental costs. Values should be verified during evaluation

estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [298]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [299]

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

For units with cooling capacities less than 65 kBtu/h:

ΔkWH = (kBtu/h) * [(1/SEERbase) – (1/SEERee)] * EFLH

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

ΔkWH = (kBtu/h) * [(1/EERbase) – (1/EERee)] * EFLH

Where:

kBtu/h = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values[300]::

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[298]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[299]Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[300] International Energy Conservation Code (IECC) 2009

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**TABLE 503.2.3(1)**
**UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS**

| EQUIPMENT TYPE | SIZE CATEGORY | SUBCATEGORY OR RATING CONDITION | MINIMUM EFFICIENCY[b] | TEST PROCEDURE[a] |
|---|---|---|---|---|
| Air conditioners, Air cooled | < 65,000 Btu/h[d] | Split system | 13.0 SEER | AHRI 210/240 |
| | | Single package | 13.0 SEER | |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Split system and single package | 10.3 EER[c] (before Jan 1, 2010) 11.2 EER[c] (as of Jan 1, 2010) | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Split system and single package | 9.7 EER[c] (before Jan 1, 2010) 11.0 EER[c] (as of Jan 1, 2010) | AHRI 340/360 |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | Split system and single package | 9.5 EER[c] 9.7 IPLV[c] (before Jan 1, 2010) 10.0 EER[c] 9.7 IPLV[g] (as of Jan 1, 2010) | |
| | ≥ 760,000 Btu/h | Split system and single package | 9.2 EER[c] 9.4 IPLV[c] (before Jan 1, 2010) 9.7 EER[c] 9.4 IPLV[c] (as of Jan 1, 2010) | |
| Through-the-wall, Air cooled | < 30,000 Btu/h[d] | Split system | 10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010) | AHRI 210/240 |
| | | Single package | 10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010) | |
| Air conditioners, Water and evaporatively cooled | < 65,000 Btu/h | Split system and single package | 12.1 EER | AHRI 210/240 |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Split system and single package | 11.5 EER[c] | |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Split system and single package | 11.0 EER[c] | AHRI 340/360 |
| | ≥ 240,000 Btu/h | Split system and single package | 11.5 EER[c] | |

For SI:  1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. IPLVs are only applicable to equipment with capacity modulation.
c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
d. Single-phase air-cooled air conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

SEERee          = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

EERbase         = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2006 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1

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

= Actual installed

EFLH = cooling equivalent full load hours; see table below for default values:

| Zone | Equivalent Full Load Hours Cooling (EFLHI)[301] |
|---|---|
| 1 (Rockford) | 816 |
| 2 (Chicago) | 819 |
| 3 (Springfield) | 1001 |
| 4 (Belleville) | 1261 |
| 5 (Marion) | 819 |

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

$$\Delta kWH = (60) * [(1/13) - (1/15)] * 816$$

$$= 502 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW_{SSP} = (kBtu/h * (1/EERbase - 1/EERee)) * CF_{SSP}$$

$$\Delta kW_{PJM} = (kBtu/h * (1/EERbase - 1/EERee)) * CF_{PJM}$$

Where:

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [302]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [303]

---

[301] Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. 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. The Ohio values were adjusted base on CCD for IL locations. Further study recommended for IL specific building types.

302 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

303 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

$\Delta kW_{SSP}$ = (60) * [(1/13) − (1/15)] * .913

= 0.562

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**MEASURE CODE: CI-HVC-SPUA-V01-060112**

average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

## 6.4.15  Steam Trap Replacement or Repair [304]

**DESCRIPTION**

The measure is for the repair or replacement of faulty steam traps that are allowing excess steam to escape and thereby increasing steam generation.  The measure is applicable to commercial applications, commercial HVAC (low pressure steam), low pressure industrial applications, medium pressure industrial applications, applications and high pressure industrial applications.  Maximum pressure for this measure is 300 psig.

This measure was developed to be applicable to the following program types: TOS, RF.  If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

Customers must have leaking traps to qualify for rebates.  However, if a commercial customer opts to replace all traps without inspection, rebates and the savings are discounted to take into consideration the fact that some traps are being replaced that have not yet failed.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline criterion is a faulty steam trap in need of replacing.  No minimum leak rate is required.  Any leaking or blow through trap can be repaired or replaced.  If a commercial customer chooses to repair or replace all the steam traps at the facility without verification, the savings are adjusted.   Savings for commercial full replacement projects arereduced by the percentage of traps found to be leaking on average from the studies listed.  If an audit is performed on a commercial site, then the leaking and blowdown can be adjusted.

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**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 6 years[305]

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[304]High Impact Measure

[305]Source paper is the Resource Solutions Group "Steam Traps Revision #1" dated August 2011.   Primary studies used to prepare the source paper include Enbridge Steam Trap Survey, KW Engineering Steam Trap Survey, Enbridge Steam Saver Program 2005, Armstrong Steam Trap Survey, DOE Federal Energy Management Program Steam Trap Performance Assessment, Oak Ridge National Laboratory Steam System Survey Guide, KEMA Evaluation of PG&E's Steam Trap Program, Sept. 2007.  Communication with vendors suggested a inverted bucket steam trap life typically in the range of 5 - 7 years, float and thermostatic traps 4- 6 years, float and thermodynamic disc traps of 1 - 3 years.  Cost does not include installation.

**DEEMED MEASURE COST**

| Steam System | Cost per trap[306] ($) |
|---|---|
| Commercial Dry Cleaners | 77 |
| Commercial Heating , low pressure steam | 77 |
| Industrial Medium Pressure >15 psig psig < 30 psig | 180 |
| Steam Trap, Industrial Medium Pressure ≥30 <75 psig | 223 |
| Steam Trap, Industrial High Pressure ≥75 <125 psig | 276 |
| Steam Trap, Industrial High Pressure ≥125 <175 psig | 322 |
| Steam Trap, Industrial High Pressure ≥175 <250 psig | 370 |
| Steam Trap, Industrial High Pressure ≥250 psig | 418 |
| Steam Trap, Industrial Medium Pressure ≥30 <75 psig | 223 |
| Steam Trap, Industrial High Pressure ≥75 <125 psig | 276 |
| Steam Trap, Industrial High Pressure ≥125 <175 psig | 322 |
| Steam Trap, Industrial High Pressure ≥175 <250 psig | 370 |
| Steam Trap, Industrial High Pressure ≥250 psig | 418 |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

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[306] Ibid.

**COINCIDENCE FACTOR**

**N/A**

---

<div align="center">

**Algorithm**

</div>

---

**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

$$\Delta therm = S * (Hv/B) * Hours * A * L / 100{,}000$$

Where:

S   = Maximu theoretical steam loss per trap

| Steam System | Avg Steam Loss[307] (lb/hr/trap) |
|---|---|
| Commercial Dry Cleaners | 38.1 |
| Commercial Heating LPS | 13.8 |
| Industrial Low Pressure, <15 psig | 13.8 |
| Industrial Medium Pressure >15 psig < 30 psig | 12.7 |
| Steam Trap, Industrial Medium Pressure ≥30 <75 psig | 19 |
| Steam Trap, Industrial High Pressure ≥75 <125 psig | 67.9 |
| Steam Trap, Industrial High Pressure ≥125 <175 psig | 105.8 |
| Steam Trap, Industrial High Pressure ≥175 <250 psig | 143.7 |
| Steam Trap, Industrial High Pressure ≥250 psig | 200.5 |

---

[307] Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

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Hv = Heat of vaporization of steam

| Steam System | Heat of Vaporization[308] (Btu/lb) |
|---|---|
| Commercial Dry Cleaners | 890 |
| Industrial Low Pressure ≤15 psig | 951 |
| Industrial Low Pressure ≤15 psig | 951 |
| Industrial Medium Pressure >15 psig < 30 psig | 945 |
| Steam Trap, Industrial Medium Pressure ≥30 <75 psig | 928 |
| Steam Trap, Industrial High Pressure ≥75 <125 psig | 894 |
| Steam Trap, Industrial High Pressure ≥125 <175 psig | 868 |
| Steam Trap, Industrial High Pressure ≥175 <250 psig | 846 |
| Steam Trap, Industrial High Pressure ≥250 psig | 820 |

B = Boiler efficiency

= custom, if unknown 0.8[309]

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[308]Heat of vaporization of steam at the inlet pressure to the steam trap.  Implicit assumption that the average boiler nominal pressure where the vaporization occurs, is essentially that same pressure.  Reference Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

[309]California Energy Commission Efficiency Data for Steam Boilers as sited in Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

Hours    = Annual operating hours of steam plant

| Steam System | Hours/Yr[310] | Zone |
|---|---|---|
| Commercial Dry Cleaners | 2,425 | |
| Industrial Low Pressure ≤15 psig | 7,752 | |
| Industrial Medium Pressure >15 psig < 30 psig | 7,752 | |
| Steam Trap, Industrial Medium Pressure ≥30 <75 psig | 7,752 | |
| Steam Trap, Industrial High Pressure ≥75 <125 psig | 7,752 | |
| Steam Trap, Industrial High Pressure ≥125 <175 psig | 7,752 | |
| Steam Trap, Industrial High Pressure ≥175 <250 psig | 7,752 | |
| Steam Trap, Industrial High Pressure ≥250 psig | 7,752 | |
| Industrial Medium Pressure >15 psig < 30 psig | 7,752 | |
| Steam Trap, Industrial Medium Pressure ≥30 <75 psig | 7,752 | |
| Commercial Heating LPS[311] | 4,272 | 1 (Rockford) |
| | 4,029 | 2 (Chicago O'Hare) |
| | 3,406 | 3 (Springfield) |
| | 2,515 | 4 (Belleville) |
| | 2,546 | 5 (Marion) |

A      = Adjustment factor

     = 50%[312]

This factor is to account for reducing the maximum theortical steam flow (S) to the average steam flow (the Enbridge factor).

---

[310]Resource Solutions Group "Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study.

[311]Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table

[312]Enbridge adjustment factor used as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011 and DOE Federal Energy Management Program Steam Trap Performance Assessment.

L  = Leaking & blow-thru

L is 1.0 when applied to the replacment of an individual leaking trap.  If a number of steam traps are replaced and the system has not been audited, the leaking and blow-thru is applied to reflect the assumed percentage of steam traps that were actually leadking and needed replaceing.  A custom value can be utilized if a supported by an evaluation.

| Steam System | %[313] |
|---|---|
| Custom | Custom |
| Commercial Dry Cleaners | 27% |
| Industrial Low Pressure ≤15 psig | 16% |
| Industrial Medium Pressure >15 psig | 16% |
| Commercial Heating LPS | 27% |

---

**EXAMPLE**

For example, a commercial dry cleaning facility with the default hours of operation and boiler efficiency;

ΔTherms = S * (Hv/B) * Hours * A * L
= 38.1 lbs/hr/trap * (890 Btu/lb / 80%)/100,000 * 2,425 * 50% * 27%  =
138.8 therms per trap

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**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-STRE-V01-060112**

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[313]Dry cleaners survey data as referenced in Resource Solutions Group "Steam Traps Revision #1" dated August 2011.

## 6.4.16 Variable Speed Drives for HVAC

### DESCRIPTION

This measure is applied to variable speed drives (VSD) which are installed on the following HVAC system applications: chilled water pump, hot water pumps, supply fans, return fans. All other VSD applications require custom analysis by the implementer. The VSD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result.

This measure was developed to be applicable to the following program types: TOS, RF. If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The VSD is applied to a motor which does not have a VSD. The application must have a variable load and installation is to include the necessary controls. Savings are based on application of VSDs to a range of baseline load conditions including no control, inlet guide vanes, outlet guide vanes and throttling valves.

### DEFINITION OF BASELINE EQUIPMENT

The time of sale baseline is a new motor installed without a VSD or other methods of control. Retrofit baseline is an existing motor operating as is. Retrofit baselines may or may not include guide vanes, throttling valves or other methods of control. This information shall be collected from the customer.

Installations of new equipment with VSDs which are required by IECC 2009 as adopted by the State of Illinois are not eligible for incentives.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for HVAC application is 15 years;[314] measure life for process is 10 years.[315]

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[314] Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
[315] DEER 2008

**DEEMED MEASURE COST**

Customer provided costs will be used when available.  Default measure costs[316] are noted below for up to 20 hp motors.  Custom costs must be gathered from the customer for motor sizes not listed below.

| HP | Cost |
|---|---|
| 1 -5 HP | $ 1,330 |
| 7.5 HP | $ 1,622 |
| 10 HP | $ 1,898 |
| 15 HP | $ 2,518 |
| 20 HP | $ 3,059 |

**DEEMED O&M COST ADJUSTMENTS**

There are no expected O&M savings associated with this measure

**LOADSHAPE**

Loadshape C39 - VFD - Supply fans <10 HP

Loadshape C40 - VFD - Return fans <10 HP

Loadshape C41 - VFD - Exhaust fans <10 HP

Loadshape C42 - VFD - Boiler feedwater pumps <10 HP

Loadshape C43 - VFD - Chilled water pumps <10 HP

Loadshape C44 - VFD Boiler circulation pumps <10 HP

Loadshape C48 - VFD Boiler draft fans <10 HP

Loadshape C49 - VFD Cooling Tower Fans <10 HP

**COINCIDENCE FACTOR**

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$\Delta kWh = kW_{connected} * Hours * ESF$

Where:

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[316]Ohio TRM 8/6/2010 varies by motor/fan size based on equipment costs from Granger 2008 Catalog pp 286-289, average across available voltages and models.  Labor costs from RS Means Data 2008   Ohio average cost adjustment applied.

$kW_{Connected}$ = kW of equipment is calculated using motor efficiency.

(HP * .746 kw/hp* load factor)/motor efficiency

Motors are assumed to have a load factor of 70% for calculating KW if actual values cannot be determined[317]. Custom load factor may be applied if known. Actual motor efficiency shall be used to calculate KW. If not known a default value of 93% shall be used.[318]

| HP | BHP | Load Factor | kW Connected[319] |
|---|---|---|---|
| 5 HP | 5 | 80% | 3.23 |
| 7.5 HP | 7.5 | 80% | 4.84 |
| 10 HP | 10 | 80% | 6.45 |
| 15 HP | 15 | 80% | 9.68 |
| 20 HP | 20 | 80% | 12.90 |

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type[320]. When available, actual hours should be used.

| Building Type | | Pumps and fans |
|---|---|---|
| College/University | | 4216 |
| Grocery | | 5840 |
| Heavy Industry | | 3585 |
| Hotel/Motel | | 6872 |
| Light Industry | | 2465 |
| Medical | | 6871 |
| Office | | 1766 |
| Restaurant | | 4654 |
| Retail/Service | | 3438 |
| School(K-12) | | 2203 |
| Warehouse | | 3222 |
| Average=Miscellaneous | | 4103 |

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[317]Com Ed TRM June 1, 2010
[318]Ohio TRM 8/6/2010 pp207-209, Com Ed Trm June 1, 2010.
[319]Field data from Illinois evaluations, Navigant, 2011.
[320]Com Ed Trm June 1, 2010 page 139.

ESF = Energy savings factor varies by VFD application.

| Application | ESF[321] |
|---|---|
| Hot Water Pump | 0.482 |
| Chilled Water Pump | 0.432 |
| Constant Volume Fan | 0.535 |
| Air Foil/inlet Guide Vanes | 0.227 |
| Forward Curved Fan, with discharge dampers | 0.179 |
| Forward Curved Inlet Guide Vanes | 0.092 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW = kW_{connected} * CF$

Where:

CF = Summer coincidence peak factor varies by VFD application.[322] Values listed below are based on typical peak load for the listed application. When possible the actual coincidence factor should be calculated.

| Application | CF |
|---|---|
| Hot Water Pump | 0 |
| Chilled Water Pump | 0.299 |
| Constant Volume Fan | 0.348 |
| Air Foil/inlet Guide Vanes | 0.13 |
| Forward Curved Fan, with discharge dampers | 0.136 |
| Forward Curved Inlet Guide Vanes | 0.03 |
| Custom Process | custom |

**FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION**

There are no expected fossil fuel impacts for this measure.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[321]CL&P and UI Program Savings Documentation for 2008 Program Year. Average of hours across all building types. http://www.ctsavesenergy.com/files/Final%202008%20Program%20Savings%20Document.pdf.
[322]Ibid

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-VSDH-V01-060112**

## 6.5 Lighting End Use

The commercial lighting measures use a standard set of variables for hours or use, waste heat factors, coincident factors and HVAC interaction effects. This table has been developed based on information provided by the various stakeholders. For ease of review, the table is included here and referenced in each measure. Once the final table has been approved, it will be added to the measures for ease of use.

| Building Type | Fixture Annual Operating Hours[323] | Screw based bulb Annual Operating hours[324] | WHFe[325] | CF[326] | WHFd[327] | IFTherms[328] |
|---|---|---|---|---|---|---|
| Office | 4,439 | 3,088 | 1.25 | 0.66 | 1.30 | 0.016 |
| Grocery | 5,802 | 3,650 | 1.43 | 0.69 | 1.52 | 0.012 |
| Healthcare Clinic | 5,095 | 4,207 | 1.34 | 0.75 | 1.57 | 0.008 |
| Hospital | 6,038 | 4,207 | 1.35 | 0.75 | 1.69 | 0.011 |
| Heavy Industry | 5,041 | 2,629 | 1.03 | 0.89 | 1.06 | 0.008 |
| Light Industry | 5,360 | 2,629 | 1.03 | 0.92 | 1.06 | 0.008 |
| Hotel/Motel Common Areas | 5,311 | 4,542 | 1.15 | 0.21 | 1.51 | 0.022 |
| Hotel/Motel Guest Rooms | 777 | 777 | 1.15 | 0.21 | 1.51 | 0.022 |
| Hotel/Motel Guest Rooms with electric heat | 777 | 777 | 0.69 | 0.21 | 0.09 | 0.00 |
| High School/Middle School | 4,311 | 2,327 | 1.23 | 0.22 | 0.74 | 0.017 |

[323]Fixtures hours of use are primarily derived from the default PY4 values developed for ComEd based on DEER 2005, DEER 2008, FY1 and FY2 evaluation results. Lighting introwp.doc. Values for office, grocery, light industry, restaurant, retail/service and warehouse are an average of the PY4 values and AmerEn Missouri, March 2011 Final Report: Evaluation of Business Energy Efficiency Program Custom and Standard Incentives. Hotel/Motel common areas is the DEER 2008 average across all non-guest room spaces and guest rooms is the average of hotel and motel guest room values from DEER 2008. Elementary School is from Ameren Missouri evaluation results. Multi-family common area value based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010. Miscellaneous is an average of all indoor spaces.

[324]Hours of use for screw based bulbs are derived from DEER 2008 by building type for cfls. Garage, exterior and multi-family common area values are from the Hours of Use Table in this document. Miscellaneous is an average of interior space values. Some building types are averaged when DEER has two values: these include office, restaurant and retail. Healthcare clinic uses the hospital value.

[325]The Waste Heat Factor for Energy is developed using EQuest models for various building types averaged across 5 climate zones for Illinois for the following building types: office, grocery, healthcare/clinic, manufacturing, motel, high school, hospital, elementary school, restaurant, retail, college and warehouse. Exterior and garage values are 1, miscellaneous is an average of all indoor spaces.

[326]Waste Heat Factor for Demand is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

[327]IF Therms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

[328]Hotel/Motel guest rooms are presented with either electric heat or gas heat; values chosen should match the fuel type in the space.

| Building Type | Fixture Annual Operating Hours[329] | Screw based bulb Annual Operating hours[330] | WHFe[331] | CF[332] | WHFd[333] | IFTherms[334] |
|---|---|---|---|---|---|---|
| Elementary School | 2,422 | 2,118 | 1.21 | 0.22 | 1.33 | 0.019 |
| Restaurant | 3,673 | 4,784 | 1.34 | 0.80 | 1.65 | 0.023 |
| Retail/Service | 4,719 | 2,935 | 1.24 | 0.83 | 1.44 | 0.024 |
| College/University | 3,540 | 2,588 | 1.14 | 0.56 | 1.50 | 0.021 |
| Warehouse | 4,746 | 4,293 | 1.16 | 0.70 | 1.17 | 0.015 |
| Garage | 3,540 | 3,540 | 1.00 | 1.00 | 1.00 | 0.000 |
| Garage, 24/7 lighting[335] | 8,766 | 8,766 | 1.00 | 1.00 | 1.00 | 1.00 |
| Exterior | 4,903 | 4,903 | 1.00 | 0.00 | 1.00 | 0.000 |
| Multi-family Common Areas | 5,950 | 5,950 | 1.34 | 0.75 | 1.57 | 0.015 |
| Miscellaneous | 4,576 | 3,198 | 1.24 | 0.66 | 1.46 | 0.000 |
| Uncooled Building | Varies | varies | 1.00 | varies | varies | varies |

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[329]Fixtures hours of use are primarily derived from the default PY4 values developed for ComEd based on DEER 2005, DEER 2008, FY1 and FY2 evaluation results.  Lighting introwp.doc. Values for office, grocery, light industry, restaurant, retail/service and warehouse are an average of the PY4 values and AmerEn Missouri, March 2011 Final Report: Evaluation of Business Energy Efficiency Program Custom and Standard Incentives. Hotel/Motel common areas is the DEER 2008 average across all non-guest room spaces and guest rooms is the average of hotel and motel guest room values from DEER 2008. Elementary School is from Ameren Missouri evaluation results.  Multi-family common area value based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.  Miscellaneous is an average of all indoor spaces.

[330]Hours of use for screw based bulbs are  derived from  DEER 2008 by building type for cfls.  Garage, exterior and multi-family common area values are from the Hours of Use Table in this document.  Miscellaneous is an average of interior space values. Some building types are averaged when DEER has two values: these include office, restaurant and retail. Healthcare clinic uses the hospital value.

[331]The Waste Heat Factor for Energy is developed using EQuest models for various building types averaged across 5 climate zones for Illinois for the following building types:  office, grocery, healthcare/clinic, manufacturing, motel, high school, hospital, elementary school, restaurant, retail, college and warehouse. Exterior and garage values are 1, miscellaneous is an average of all indoor spaces.

[332]Waste Heat Factor for Demand is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

[333]IF Therms value is developed using EQuest models consistent with methodology for Waste Heat Factor for Energy.

[334]Hotel/Motel guest rooms are presented with either electric heat or gas heat; values chosen should match the fuel type in the space.

[335] Use of this value requires documentation that the lighting is required to be on 24 hours a day,7 days a week for 365.25 days per year.

## 6.5.1   Commercial Standard CFL

### DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of an incandescent screw-in bulb. This characterization assumes that the CFL is installed in a commercial location. If the implementation strategy means that the final installation location of the bulb is not known, deemed assumptions are provided. If however it is known, the values are dependent on the building type.

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. Production of 100W, standard efficacy incandescent lamps ends in 2012 followed by restrictions on 75W in 2013 and 60W and 40W 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 and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure.  For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

This measure was developed to be applicable to the following program types: TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

### 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

The baseline equipment is assumed to be a standard incandescent light bulb, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb becomes 53W in June 2012 and 60W and 40W bulbs become 43W and 29W respectively in June 2014 Annual savings are reduced to account for this baseline shift within the life of a measure and the measure life is reduced to account for the baseline replacements becoming equivalent to a current day CFL by June 2020.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life (number of years that savings should be claimed) should be calculated by dividing the rated life of the bulb (10,000 hours[336]) by the run hours. For example using Miscellaneous at 4,589 hours would give 2.2 years.  When the number of years exceeds June 2020, the number of years to that date should be used.

**DEEMED MEASURE COST**

The incremental capital cost assumption for all bulbs is $1.90, from June 2012 – May 2013, $1.80 from June 2013 – May 2014 and $1.50 from June 2014 – May 2015[337].

**DEEMED O&M COST ADJUSTMENTS**

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below[338]:

| Lumen Range | NPV of baseline replacement costs | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $11.81 | $11.81 | $11.81 |
| 1050-1489 | $8.60 | $11.81 | $11.81 |
| 750-1049 | $4.68 | $8.60 | $11.81 |
| 310-749 | $4.68 | $8.60 | $11.81 |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| CFL wattage | Levelized annual replacement cost savings | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $5.86 | $5.86 | $5.86 |
| 1050-1489 | $4.26 | $5.86 | $5.86 |
| 750-1049 | $2.32 | $4.26 | $5.86 |
| 310-749 | $2.32 | $4.26 | $5.86 |

Note incandescent bulbs in lumen range 2601 – 3300 are exempt from EISA. For these bulbs there is no baseline shift and so the assumption is a baseline replacement cost of $0.50 every 0.2 year (1000 hr rated life/4589 run

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[336]Energy Star bulbs have a rated life of at least 8000 hours. In commercial settings you expect significantly less on/off switching than residential and so a rated life assumption of 10,000 hours is used.

[337]Based on Northeast Regional Residential Lighting Strategy (RLS) report, prepared by EFG, D&R International, Ecova and Optimal Energy, applying sales weighting and phase-in of EISA regulations. Assumption is $2.50 for CFL over three years and $0.6 for baseline in 2012, $0.70 in 2013 and $1.00 in 2014 as more expensive EISA qualified bulbs become baseline.

[338]Calculation is based on average hours of use assumption, see 'C&I Standard CFL O&M calc.xls' for more details.

hours).

**LOADSHAPE**

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

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## Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = ((WattsBase-WattsEE)/1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Actual (if retrofit measure) or based on lumens of CFL bulb and program year purchased:

| Minimum Lumens | Maximum Lumens | Incandescent Equivalent Pre-EISA 2007 (WattsBase) | Incandescent Equivalent Post-EISA 2007 (WattsBase) | Effective date from which Post – EISA 2007 assumption should be used |
|---|---|---|---|---|
| 2601 | 3300 | 150 | 150 | N/A 2600+ lumen bulbs are exempt from EISA. |
| 1490 | 2600 | 100 | 72 | June 2012 |
| 1050 | 1489 | 75 | 53 | June 2013 |
| 750 | 1049 | 60 | 43 | June 2014 |
| 310 | 749 | 40 | 29 | June 2014 |

WattsEE = Actual wattage of CFL purchased or installed

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%[339] if application form completed with sign off that equipment is not placed into storage

If sign off form not completed assume the following 3 year ISR assumptions:

| Weigted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|
| 69.5%[340] | 15.4% | 13.1% | 98.0%[341] |

---

[339]Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

[340] 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption. Note these evaluations did not look at C&I specific installations but until a more appropriate C&I evaluation is performed, the Residential assumptions are applied.

[341] The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

Hours = Average hours of use per year are provided in Reference Table in Section 6.4, Screw based bulb annual operating hours, for each building type[342]. If unknown use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in Reference Table in Section 6.4. If unknown, use the Miscellaneous value.

**Mid Life Baseline Adjustment**

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for 2600+ lumen bulbs) the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, 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 adjustment factors are provided below.

| Lumen Range | Pre EISA WattsBase | Post EISA WattsBase | CFL Equivalent | Delta Watts Before EISA | Delta Watts After EISA | Mid Life Adjustment | Adjustment made from date |
|---|---|---|---|---|---|---|---|
| 2601-3300 | 150 | 150 | 42 | 108 | 108 | - | - |
| 1490-2600 | 100 | 72 | 25 | 75 | 47 | 63% | N/A (2012 is already post EISA) |
| 1050-1489 | 75 | 53 | 20 | 55 | 33 | 60% | June, 2013 |
| 750-1049 | 60 | 43 | 14 | 46 | 29 | 63% | June, 2014 |
| 310-749 | 40 | 29 | 11 | 29 | 18 | 62% | June, 2014 |

For example, a 20W standard CFL, 1200 lumen is installed in an office in 2012 and sign off form provided:

ΔkWH = ((75-20)/1000)*1.0*3088*1.25

= 212 kWh

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (212 * 0.6 =) 127 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW= ((WattsBase-WattsEE)/1000) * ISR * WHFd * CF

Where:

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[342]Based on ComEd analysis taking DEER 2008 values and averaging with PY1 and PY2 evaluation results.

WHFd        = Waste heat factor for demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 6.4.  If unknown, use the Miscellaneous value..

CF          = Summer Peak Coincidence Factor for measure is provided in the Reference Table in Section 6.4.  If unknown, use the Miscellaneous value..

Other factors as defined above

---

For example, a 20W standard CFL, 1200 lumen is installed in an office in 2012 and sign off form provided:

$\Delta kW$ = ((75-20)/1000)*1.0*1.3*0.66

= 0.047kW

---

**NATURAL GAS ENERGY SAVINGS**

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

$\Delta Therms^{343}$ = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms        = 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 effecent lighting. Values are provided in the Reference Table in Section 6.4.  If unknown, use the Miscellaneous value.

Other factors as defined above

---

For example, a 20W standard CFL, 1200 lumen is installed in an office in 2012 and sign off form provided:

$\Delta Therms$ = (((75-20)/1000)* 1.0*3088*-0.016

= - 2.7 Therms

---

**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 Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see C&I Standard CFL O&M

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[343]Negative value because this is an increase in heating consumption due to the efficient lighting.

calc.xls). The key assumptions used in this calculation are documented below[344]:

| | Standard Incandescent | Efficient Incandescent | CFL |
|---|---|---|---|
| Replacement Cost | $0.50 | $1.50 | $2.50 |
| Component Rated Life (hrs) | 1000 | 1000[345] | 10,000 |

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below[346]:

| | NPV of baseline replacement costs | | |
|---|---|---|---|
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $12.86 | $12.86 | $12.86 |
| 1050-1489 | $9.36 | $12.86 | $12.86 |
| 750-1049 | $5.10 | $9.36 | $12.86 |
| 310-749 | $5.10 | $9.36 | $12.86 |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement cost savings | | |
|---|---|---|---|
| CFL wattage | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $6.38 | $6.38 | $6.38 |
| 1050-1489 | $4.64 | $6.38 | $6.38 |
| 750-1049 | $2.53 | $4.64 | $6.38 |
| 310-749 | $2.53 | $4.64 | $6.38 |

Note incandescent bulbs in lumen range 2601 – 3300 are exempt from EISA. For these bulbs there is no baseline shift and so the assumption is a baseline replacement cost of $0.50 every 0.2 year (1000 hr rated life/4576 run hours).

MEASURE CODE: CI-LTG-CCFL-V01-060112

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[344] Calculation is based on average hours of use assumption.

[345] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

[346] Calculation is based on average hours of use assumption, see 'C&I Standard CFL O&M calc.xls' for more details.

## 6.5.2   LED Bulbs and Fixtures

### DESCRIPTION

This characterization provides savings assumptions for a variety of LED lamps including Omnidirectional (e.g. A-Type lamps), Decorative (e.g. Globes and Torpedoes) and Directional (PAR Lamps, Reflectors, MR16), and fixtures including refrigerated case , recessed and outdoor/garage fixtures.

This measure was developed to be applicable to the following program types:  TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, new lamps must be Energy Star labeled.  Lamps and fixtures should be found in the reference tables below.  Fixtures must be Energy Star labeled or on the Design Lights Consortium qualifying fixture list.

### DEFINITION OF BASELINE EQUIPMENT

Refer to the baseline tables.  In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology.  In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014.  To account for this legislation, a mid life adjustment is calculated for Standard Omnidirectional screw based bulbs whose baseline assumes incandescent lamps.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year – see reference table "LED component Costs and Lifetime."  The analysis period is the same as the lifetime, capped at 15 years.  (15 years from GDS Measure Life Report, June 2007).

### DEEMED MEASURE COST

Wherever possible, actual incremental costs should be used. Refer to reference table "LED component Cost & Lifetime" for defaults.

### DEEMED O&M COST ADJUSTMENTS

Refer to reference table "LED component Cost & Lifetime."

### LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting
Loadshape C07 - Grocery/Conv. Store Indoor Lighting
Loadshape C08 - Hospital Indoor Lighting
Loadshape C09 - Office Indoor Lighting
Loadshape C10 - Restaurant Indoor Lighting
Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

Where:

$Watts_{base}$ = Input wattage of the existing system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = New Input wattage of EE fixture. See the "LED New and Baseline Assumptions" table.

For ENERGY STAR rated lamps the following lumen equivalence tables should be used:

Omnidirectional Lamps - ENERGY STAR Minimum Luminous Efficacy = 50Lm/W for <10W lamps and 55Lm/W for >=10W lamps.

| Nominal wattage of lamp to be replaced (Watts$_{base}$) | Minimum initial light output of LED lamp (lumens) | Post EISA 2012-2014 Incandescent wattage | Post EISA 2020 requirement (45Lm/W) | LED Wattage (Watts$_{EE}$) | Delta Watts (pre EISA) | Delta Watts (post EISA 2012-2014) | Effective date for post EISA 2012-2014 assumption | Delta Watts (post EISA 2020) |
|---|---|---|---|---|---|---|---|---|
| 25 | 200 | 25 | 25 | 4.0 | 21.0 | 21.0 | Exempt | 21.0 |
| 35 | 325 | 29 | 7.2 | 6.5 | 28.5 | 22.5 | June 2014 | 0.7 |
| 40 | 450 | 29 | 10 | 9.0 | 31.0 | 20.0 | June 2014 | 1.0 |
| 60 | 800 | 43 | 17.8 | 14.5 | 45.5 | 28.5 | June 2014 | 3.3 |
| 75 | 1,100 | 53 | 24.4 | 20.0 | 55.0 | 33.0 | June 2013 | 4.4 |
| 100 | 1,600 | 72 | 35.6 | 29.1 | 70.9 | 42.9 | June 2012 | 6.5 |
| 125 | 2,000 | 72 | 44.4 | 36.4 | 88.6 | 35.6 | June 2012 | 8.0 |
| 150 | 2,600 | 150 | 150 | 47.3 | 102.7 | 102.7 | Exempt | 102.7 |

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Decorative Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for all lamps

| Nominal wattage of lamp to be replaced (Watts$_{base}$) | Minimum initial light output of LED lamp (lumens) | LED Wattage (Watts$_{EE}$) | Delta Watts |
|---|---|---|---|
| 10 | 70 | 1.75 | 8.25 |
| 15 | 90 | 2.25 | 12.75 |
| 25 | 150 | 3.75 | 21.25 |
| 40 | 300 | 7.5 | 32.5 |
| 60 | 500 | 12.5 | 47.5 |

Directional lamps are exempt from EISA regulations.

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamp diameter <= 20/8 inch (PAR 20 and smaller) and 45 Lm/W for lamp diameter > 20/8 inch (greater than PAR20).

| Nominal wattage of lamp to be replaced (Watts$_{base}$) | Minimum initial light output of LED lamp (lumens) | LED Wattage (Watts$_{EE}$) | Delta Watts |
|---|---|---|---|
| 25 | 250 | 6.25 | 18.75 |
| 35 | 350 | 8.75 | 26.25 |
| 40 | 400 | 10.0 | 30.0 |
| 60 | 600 | 15.0 | 45.0 |
| 75 | 750 | 18.75 | 56.25 |
| 100 | 1000 | 25.0 | 75.0 |
| 125 | 1250 | 31.25 | 93.75 |
| 150 | 1500 | 37.5 | 112.5 |

Directional lamps are exempt from EISA regulations.

Hours = Average hours of use per year are provided in the Reference Table in Section 6.4, Screw based bulb annual operating hours, for each building type. If unknown, use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in the Referecne Table in Section 6.4. If unknown, use the Miscellaneous value.

ISR = In service Rate -the percentage of units rebated that actually get installed. Use 100% unless an evaluation shows a lesser value.

**Mid Life Baseline Adjustment**

During the lifetime of a standard Omnidirectional LED, the baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for 2600+ lumen bulbs) the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm)

should be claimed for the first two years, but a reduced annual savings (calculated energy savings above multipled by the adjustment factor in the table below) claimed for the remainder of the measure life.

Omnidirectional Lamps

| Nominal wattage of lamp to be replaced (Watts_base) | Minimum initial light output of LED lamp (lumens) | Delta Watts (pre EISA) | Delta Watts (post EISA 2012-2014) | Mid Life adjustment 1 from first year savings | Adjustment made from date | Delta Watts (post EISA 2020) | Mid Life adjustment 2 (made from June 2020) from first year savings |
|---|---|---|---|---|---|---|---|
| 25 | 200 | 21.0 | 21.0 | Exempt | Exempt | 21.0 | Exempt |
| 35 | 325 | 28.5 | 22.5 | 78.9% | June 2014 | 0.7 | 2.5% |
| 40 | 450 | 31.0 | 20.0 | 64.5% | June 2014 | 1.0 | 3.2% |
| 60 | 800 | 45.5 | 27.6 | 60.7% | June 2014 | 3.3 | 7.3% |
| 75 | 1,100 | 55.0 | 33.0 | 60.0% | June 2013 | 4.4 | 8.0% |
| 100 | 1,600 | 70.9 | 42.9 | 60.5% | June 2012 | 6.5 | 9.2% |
| 125 | 2,000 | 88.6 | 35.6 | 40.2% | June 2012 | 8.0 | 9.0% |
| 150 | 2,600 | 102.7 | 102.7 | Exempt | Exempt | 102.7 | Exempt |

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For example, a 9W LED lamp, 450 lumens, is installed in an office in 2012:

$$\Delta kWH = ((40-29/1000)*1.0*3088*1.25$$

$$= 42.5 \text{ kWh}$$

This value should be claimed for two years, i.e. June 2012 – May 2014, but from June 2014 on savings for that same bulb should be reduced to (42.5 * 0.645 =) 27.4 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

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**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Referecne Table in Section 6.4. If unknown, use the Miscellaneous value.

CF = Summer Peak Coincidence Factor for measure is provided in the Referecne Table in Section 6.4. If unknown, use the Miscellaneous value.

For example, For example, a 9W LED lamp, 450 lumens, is installed in an office in 2012and sign off form provided:

$$\Delta kW = ((40\text{-}29/1000)* 1.0*1.3*0.66$$

$$= - 0.52 \text{ kW}$$

**NATURAL GAS ENERGY SAVINGS**

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

$\Delta$therms = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration 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. Values are provided in the Referecne Table in Section 6.4. If unknown, use the Miscellaneous value.

For example, For example, a 9W LED lamp, 450 lumens, is installed in an office in 2012 and sign off form provided:

$$\Delta Therms = ((40\text{-}29/1000)*1.0*3088* -0.016$$

$$= - 0.54 \text{ Therms}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

For all measures except Standard Omnidirectional lamps (which have an EISA baseline shift) the individual component lifetimes and costs are provided in the reference table section below[347].

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[347] See "LED reference tables.xls" for breakdown of component cost assumptions.

Omnidirectional Lamps:

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the LED bulb (assumed to be 25,000/4576 = 6.46 years) is calculated (see "C&I OmniDirectional LED O&M Calc.xls"). The key assumptions used in this calculation are documented below:

| | Standard Incandescent | Efficient Incandescent | CFL |
|---|---|---|---|
| Replacement Cost | $0.50 | $1.50 | $2.50 |
| Component Rated Life (hrs) | 1000 | 1000348 | 10,000 |

The Net Present Value of the baseline replacement costs for each lumen range and installation year (2012 -2016) are presented below:

| | NPV of baseline replacement costs | | |
|---|---|---|---|
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $32.23 | $32.23 | $26.78 |
| 1050-1489 | $28.66 | $32.23 | $26.78 |
| 750-1049 | $24.31 | $28.66 | $26.78 |
| 310-749 | $24.31 | $28.66 | $26.78 |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement cost savings | | |
|---|---|---|---|
| CFL wattage | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $6.94 | $6.94 | $5.76 |
| 1050-1489 | $6.17 | $6.94 | $5.76 |
| 750-1049 | $5.23 | $6.17 | $5.76 |
| 310-749 | $5.23 | $6.17 | $5.76 |

Note incandescent bulbs in lumen range <310 and >2600 are exempt from EISA. For these bulbs there is no baseline shift and so the assumption is a baseline replacement cost of $0.50 every 0.2 year (1000 hr rated life/4576 run hours).

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[348]The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

LED New and Baseline Assumptions[349]

| LED Measure Description | WattsEE | Baseline Description | WattsBASE | Basis for Watt Assumptions | LED Lamp Cost | Baseline Cost (EISA 2012-2014, EISA 2020) | Incremental Cost (EISA 2012-2014, EISA 2020) | LED Minimum Lamp Life (hrs) |
|---|---|---|---|---|---|---|---|---|
| LED Screw and Pin-based Bulbs, Omnidirectional, < 10W | See tables above | | | | $30.00 | $0.50 ($1.50, $2.50) | $29.5 ($28.50, $27.50) | 25,000 |
| LED Screw and Pin-based Bulbs, Omnidirectional, >= 10W | | | | | $40.00 | $0.50 ($1.50, $2.50) | $29.5 ($28.50, $27.50) | 25,000 |
| LED Screw and Pin-based Bulbs, Decorative | | | | | $30.00 | $1.00 | $29.00 | 25,000 |
| LED Screw-based Bulbs, Directional, < 15W | | | | | $45.00 | $5.00 | $40.00 | 35,000 |
| LED Screw-based Bulbs, Directional, >= 15W | | | | | $55.00 | $5.00 | $50.00 | 35,000 |
| LED Recessed, Surface, Pendant Downlights | 17.6 | Baseline LED Recessed, Surface, Pendant Downlights | 54.3 | 2008-2010 EVT Historical Data of 947 Measures | 50,000 | | $50.00 | |
| LED Track Lighting | 12.2 | Baseline LED Track Lighting | 60.4 | 2008-2010 EVT Historical Data of 242 Measures | 50,000 | | $100.00 | |
| LED Wall-Wash Fixtures | 8.3 | Baseline LED Wall-Wash Fixtures | 17.7 | 2008-2010 EVT Historical Data of 220 Measures | 50,000 | | $80.00 | |
| LED Portable Desk/Task Light Fixtures | 7.1 | Baseline LED Portable Desk/Task Light Fixtures | 36.2 | 2008-2010 EVT Historical Data of 21 Measures | 50,000 | | $50.00 | |

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[349] Data is based on Efficiency Vermont derived cost and actual installed wattage information.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot) | 7.1 | Baseline LED Undercabinet Shelf-Mounted Task Light Fixtures | 36.2 | 2008-2010 EVT Historical Data of 21 Measures | 50,000 | | $25.00 | |
| LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar) | 7.6 | Baseline LED Refrigerated Case Light, Horizontal or Vertical (per foot of light bar) | 15.2 | PG&E Refrigerated Case Study[350] normalized to per foot of light bar. | 50,000 | | $50.00 | |
| LED Freezer Case Light, Horizontal or Vertical (per foot) | 7.7 | Baseline LED Freezer Case Light, Horizontal or Vertical (per foot) | 18.7 | PG&E Refrigerated Case Study normalized to per foot. | 50,000 | | $50.00 | |
| LED Display Case Light Fixture (per foot) | 7.1 | Baseline LED Display Case Light Fixture | 36.2 | Modeled after LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot) | 35,000 | | $25.00 | |
| LED 2x2 Recessed Light Fixture | 44.9 | T8 U-Tube 2L-FB32 w/ Elec - 2' | 61.0 | Based on average watts of DLC qualified products as of 11/21/11 | 35,000 | | $75.00 | |
| LED 2x4 Recessed Light Fixture | 53.6 | T8 3L-F32 w/ Elec - 4' | 88.0 | Based on average watts of DLC qualified products as of 11/21/11 | 35,000 | | $125.00 | |
| LED 1x4 Recessed Light Fixture | 32.2 | T8 2L-F32 w/ Elec - 4' | 59.0 | Based on average watts of DLC qualified products as of 11/21/11 | 35,000 | | $100.00 | |
| LED High- and Low-Bay Fixtures | 160.2 | MH 250 W CWA Pulse Start | 295.0 | Based on average watts of DLC qualified products as of 11/21/11 | 35,000 | | $200.00 | |
| LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W | 18.6 | Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W | 124.3 | 2008-2010 EVT Historical Data of 2,813 Measures | 50,000 | | $125.00 | |
| LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W | 52.5 | Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W | 182.9 | 2008-2010 EVT Historical Data of 1,081 Measures | 50,000 | | $250.00 | |

[350] LED Refrigeration Case Ltg Workpaper 053007 rev1,  May 30, 2007

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W | 116.8 | Baseline LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W | 361.4 | 2008-2010 EVT Historical Data of 806 Measures | 50,000 | | $375.00 | |
| LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W | 18.6 | Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W | 124.3 | 2008-2010 EVT Historical Data of 2,813 Measures | 50,000 | | $125.00 | |
| LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W | 52.5 | Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - 75W | 182.9 | 2008-2010 EVT Historical Data of 1,081 Measures | 50,000 | | $250.00 | |
| LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W | 116.8 | Baseline LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W | 361.4 | 2008-2010 EVT Historical Data of 806 Measures | 50,000 | | $375.00 | |
| LED Parking Garage/Canopy, < 30W | 18.6 | Baseline LED Parking Garage/Canopy, < 30W | 124.3 | 2008-2010 EVT Historical Data of 2,813 Measures | 50,000 | | $125.00 | |
| LED Parking Garage/Canopy, 30W - 75W | 52.5 | Baseline LED Parking Garage/Canopy, 30W - 75W | 182.9 | 2008-2010 EVT Historical Data of 1,081 Measures | 50,000 | | $250.00 | |
| LED Parking Garage/Canopy, >= 75W | 116.8 | Baseline LED Parking Garage/Canopy, >= 75W | 361.4 | 2008-2010 EVT Historical Data of 806 Measures | 50,000 | | $375.00 | |
| LED Wall-Mounted Area Lights, < 30W | 18.6 | Baseline LED Wall-Mounted Area Lights, < 30W | 124.3 | 2008-2010 EVT Historical Data of 2,813 Measures | 50,000 | | $125.00 | |
| LED Wall-Mounted Area Lights, 30W - 75W | 52.5 | Baseline LED Wall-Mounted Area Lights, 30W - 75W | 182.9 | 2008-2010 EVT Historical Data of 1,081 Measures | 50,000 | | $250.00 | |
| LED Wall-Mounted Area Lights, >= 75W | 116.8 | Baseline LED Wall-Mounted Area Lights, >= 75W | 361.4 | 2008-2010 EVT Historical Data of 806 Measures | 50,000 | | $375.00 | |
| LED Bollard, < 30W | 13.9 | Baseline LED Bollard, < 30W | 54.3 | 2008-2010 EVT Historical Data of 33 Measures | 50,000 | | $150.00 | |

| LED Bollard, >= 30W | 41.0 | Baseline LED Bollard, >= 30W | 78.0 | 2008-2010 EVT Historical Data of 15 Measures | 50,000 | | $250.00 | |
| LED Flood Light, < 15W | 8.7 | Baseline LED Flood Light, < 15W | 51.7 | Consistent with LED Screw-base Directional | 50,000 | | $35.00 | |
| LED Flood Light, >= 15W | 16.2 | Baseline LED Flood Light, >= 15W | 64.4 | Consistent with LED Screw-base Directional | 50,000 | | $45.00 | |

LED Component Costs & Lifetime[351]

| LED Component Costs and Lifetimes | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LED Measure Description | LED Minimum Lamp Life (hrs) | LED Lamp Cost Total | LED Driver Life (hrs) | LED Driver Cost Total | Baseline Technology (1) | Lamp (1) Life (hrs) | Lamp (1) Total Cost | Ballast (1) Life (hrs) | Ballast (1) Total Cost | Baseline Technology (2) | Lamp (2) Life (hrs) | Lamp (2) Total Cost |
| LED Screw and Pin-based Bulbs, Decorative | 25,000 | N/A | N/A | N/A | 53W EISA Halogen | 2,000 | $4.67 | N/A | N/A | N/A | N/A | N/A |
| LED Screw-based Bulbs, Directional, < 15W | 35,000 | N/A | N/A | N/A | 15% CFL 18W Pin Base | 10,000 | $11.62 | 40,000 | $36.00 | 85% Halogen PAR20 | 2,500 | $12.67 |
| LED Screw-based Bulbs, Directional, >=  15W | 35,000 | N/A | N/A | N/A | 15% CFL 26W Pin Base | 10,000 | $12.62 | 40,000 | $36.00 | 85% Halogen PAR30/38 | 2,500 | $12.67 |
| LED Recessed, Surface, Pendant Downlights | 50,000 | $47.50 | 70,000 | $47.50 | 40% CFL 26W Pin Base | 10,000 | $12.62 | 40,000 | $36.00 | 60% Halogen PAR30/38 | 2,500 | $12.67 |
| LED Track Lighting | 50,000 | $47.50 | 70,000 | $47.50 | 10% CMH PAR38 | 12,000 | $62.92 | 40,000 | $110.00 | 90% Halogen PAR38 | 2,500 | $12.67 |
| LED Wall-Wash Fixtures | 50,000 | $47.50 | 70,000 | $47.50 | 40% CFL 42W Pin Base | 10,000 | $15.72 | 40,000 | $67.50 | 60% Halogen PAR38 | 2,500 | $12.67 |
| LED Portable Desk/Task Light Fixtures | 50,000 | $47.50 | 70,000 | $47.50 | 50% 13W CFL Pin Base | 10,000 | $5.52 | 40,000 | $25.00 | 50% 50W Halogen | 2,500 | $12.67 |

[351] Note some measures have blended baselines. All values are provided to enable calculation of appropriate O&M impacts. Total costs include lamp, labor and disposal cost assumptions where applicable, see "LED reference tables.xls" for more information.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LED Undercabinet Shelf-Mounted Task Light Fixtures (per foot) | 50,000 | $47.50 | 70,000 | $47.50 | 50% 2' T5 Linear | 7,500 | $9.92 | 40,000 | $45.00 | 50% 50W Halogen | 2,500 | $12.67 |
| LED Refrigerated Case Light, Horizontal or Vertical (per foot) | 50,000 | $9.50 | 70,000 | $9.50 | 5' T8 | 15,000 | $2.77 | 40,000 | $9.50 | N/A | N/A | N/A |
| LED Freezer Case Light, Horizontal or Vertical (per foot) | 50,000 | $8.75 | 70,000 | $7.92 | 6' T12HO | 12,000 | $11.03 | 40,000 | $59.58 | N/A | N/A | N/A |
| LED Display Case Light Fixture (per foot) | 35,000 | $47.50 | 70,000 | $28.75 | 50% 2' T5 Linear | 7,500 | $9.92 | 40,000 | $45.00 | 50% 50W Halogen | 2,500 | $12.67 |
| LED 2x2 Recessed Light Fixture | 35,000 | $47.50 | 70,000 | $47.50 | T8 U-Tube 2L-FB32 w/ Elec - 2' | 15,000 | $24.95 | 40,000 | $52.00 | N/A | N/A | N/A |
| LED 2x4 Recessed Light Fixture | 35,000 | $72.50 | 70,000 | $47.50 | T8 3L-F32 w/ Elec - 4' | 15,000 | $17.00 | 40,000 | $35.00 | N/A | N/A | N/A |
| LED 1x4 Recessed Light Fixture | 35,000 | $47.50 | 70,000 | $47.50 | T8 2L-F32 w/ Elec - 4' | 15,000 | $11.33 | 40,000 | $35.00 | N/A | N/A | N/A |
| LED High- and Low-Bay Fixtures | 35,000 | $112.50 | 70,000 | $62.50 | 250W MH | 10,000 | $41.25 | 40,000 | $130.25 | N/A | N/A | N/A |
| LED Outdoor Pole/Arm Mounted Parking/Roadway, < 30W | 50,000 | $62.50 | 70,000 | $62.50 | 100W MH | 10,000 | $54.25 | 40,000 | $166.70 | N/A | N/A | N/A |
| LED Outdoor Pole/Arm Mounted Parking/Roadway, 30W - 75W | 50,000 | $87.50 | 70,000 | $62.50 | 175W MH | 10,000 | $48.25 | 40,000 | $110.00 | N/A | N/A | N/A |
| LED Outdoor Pole/Arm Mounted Parking/Roadway, >= 75W | 50,000 | $112.50 | 70,000 | $62.50 | 250W MH | 10,000 | $41.25 | 40,000 | $130.25 | N/A | N/A | N/A |
| LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, < 30W | 50,000 | $62.50 | 70,000 | $62.50 | 100W MH | 10,000 | $54.25 | 40,000 | $166.70 | N/A | N/A | N/A |
| LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, 30W - | 50,000 | $87.50 | 70,000 | $62.50 | 175W MH | 10,000 | $48.25 | 40,000 | $110.00 | N/A | N/A | N/A |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 75W | | | | | | | | | | | |
| LED Outdoor Pole/Arm Mounted Decorative Parking/Roadway, >= 75W | 50,000 | $112.50 | 70,000 | $62.50 | 250W MH | 10,000 | $41.25 | 40,000 | $130.25 | N/A | N/A | N/A |
| LED Parking Garage/Canopy, < 30W | 50,000 | $47.50 | 70,000 | $47.50 | 100W MH | 10,000 | $36.92 | 40,000 | $151.70 | N/A | N/A | N/A |
| LED Parking Garage/Canopy, 30W - 75W | 50,000 | $72.50 | 70,000 | $47.50 | 175W MH | 10,000 | $30.92 | 40,000 | $95.00 | N/A | N/A | N/A |
| LED Parking Garage/Canopy, >= 75W | 50,000 | $97.50 | 70,000 | $47.50 | 250W MH | 10,000 | $23.92 | 40,000 | $115.25 | N/A | N/A | N/A |
| LED Wall-Mounted Area Lights, < 30W | 50,000 | $47.50 | 70,000 | $47.50 | 100W MH | 10,000 | $36.92 | 40,000 | $151.70 | N/A | N/A | N/A |
| LED Wall-Mounted Area Lights, 30W - 75W | 50,000 | $72.50 | 70,000 | $47.50 | 175W MH | 10,000 | $30.92 | 40,000 | $95.00 | N/A | N/A | N/A |
| LED Wall-Mounted Area Lights, >= 75W | 50,000 | $97.50 | 70,000 | $47.50 | 250W MH | 10,000 | $23.92 | 40,000 | $115.25 | N/A | N/A | N/A |
| LED Bollard, < 30W | 50,000 | $47.50 | 70,000 | $47.50 | 50W MH | 10,000 | $36.92 | 40,000 | $135.50 | N/A | N/A | N/A |
| LED Bollard, >= 30W | 50,000 | $72.50 | 70,000 | $47.50 | 70W MH | 10,000 | $36.92 | 40,000 | $142.50 | N/A | N/A | N/A |
| LED Flood Light, < 15W | 50,000 | $47.50 | 70,000 | $47.50 | 25% 50W MH | 10,000 | $36.92 | 40,000 | $135.50 | 75% Halogen PAR20 | 2,500 | $12.67 |
| LED Flood Light, >= 15W | 50,000 | $47.50 | 70,000 | $47.50 | 50% 50W MH | 10,000 | $36.92 | 40,000 | $135.50 | 50% Halogen PAR30/38 | 2,500 | $12.67 |

**MEASURE CODE: CI-LTG-LEDB-V01-060112**

## 6.5.3  High Performance and Reduced WattageT8 Fixtures and Lamps

### DESCRIPTION

This measure applies to "High Performance T8" (HPT8) lamp/ballast systems that have higher lumens per watt than standard T8 systems.  This measure applies to the installation of new equipment with efficiencies that exceed that of the equipment that would have been installed following standard market practices and is applicable to time of sale as well as retrofit measures.  Retrofit measures may include new fixtures or relamp/reballast measures. In addition, options have been provided to allow for the "Reduced Wattage T8 lamps" or RWT8 lamps that result in re-lamping opportunities that produce equal or greater light levels than standard T8 lamps while using fewer watts.

This measure was developed to be applicable to the following program types: TOS, RF.
If applied to other program types, the measure savings should be verified.
The measure applies to all commercial HPT8 installations excluding new construction and major renovation or change of use measures (see lighting power density measure).  Lookup tables have been provided to account for the different types of installations. Whenever possible, actual costs and hours of use should be utilized for savings calculations. Default new and baseline assumptions have been provided in the reference tables.   Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. HPT8 configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| This measure relates to the installation of new equipment with efficiency that exceeds that of equipment that would have been installed following standard market practices. In general, the measure will include qualifying high efficiency low ballast factor ballasts paired with high efficiency long life lamps as detailed in the attached tables. High-bay applications use this system paired with qualifying high ballast factor ballasts and high performance 32 w lamps. Custom lighting designs can use qualifying low, normal or high ballast factor ballasts and qualifying lamps in lumen equivalent applications where total system wattage is reduced when calculated using the Calculation of Savings Algorithms. | This measure relates to the replacement of existing equipment with new equipment with efficiency that exceeds that of the existing equipment. In general, the retrofit will include qualifying high efficiency low ballast factor ballasts paired with high efficiency long life lamps as detailed in the attached tables.  Custom lighting designs can use qualifying low, normal or high ballast factor ballasts and qualifying lamps in lumen equivalent applications where total system wattage is reduced when calculated using the Calculation of Savings Algorithms.<br><br>High efficiency troffers (new/or retrofit) utilizing HPT8 technology can provide even greater savings. When used in a high-bay application, high-performance T8 fixtures can provide equal light to HID high-bay fixtures, while using fewer watts; these systems typically utilize high ballast factor ballasts, but qualifying low and normal ballast factor ballasts may be used when appropriate light levels are provided and overall wattage is reduced. |

### DEFINITION OF EFFICIENT EQUIPMENT

The definition of efficient equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| In order for this characterization to apply, new lamps and ballasts must be listed on the CEE website on the qualifying High Performance T8 lamps and ballasts list (http://www.cee1.org/com/com-lt/com-lt-main.php3)..<br><br>High efficiency troffers combined with high efficiency lamps and ballasts allow for fewer lamps to be used to provide a given lumen output.  High efficiency troffers must have a fixture efficiency of 80% or greater to qualify. Default values are given for a 2 lamp HPT8 fixture replacing a 3 lamp standard efficiency T8 fixture, but other configurations may qualify and the Calculation of savings algorithm used to account for base watts being replaced with EE watts.<br><br>High bay fixtures must have fixture efficiencies of 85% or greater.<br><br>RWT8 lamps: In order for this characterization to apply, new 4' and U-tube lamps must be listed on the CEE website on the qualifying Reduced Wattage High Performance T8 lamps list. (http://www.cee1.org/com/com-lt-main.php3).  2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table.  This measure assumes a lamp only purchase. | In order for this characterization to apply, new lamps and ballasts must be listed on the CEE website on the qualifying High Performance T8 lamps and ballasts list (http://www.cee1.org/com/com-lt-main.php3).<br><br>High efficiency troffers (new or retrofit kits) combined with high efficiency lamps and ballasts allow for fewer lamps to be used to provide a given lumen output. High efficiency troffers must have a fixture efficiency of 80% or greater to qualify. Default values are given for a 2 lamp HPT8 fixture replacing a 3 lamp standard efficiency T8 fixture, but other configurations may qualify and the Calculation of savings algorithm used to account for base watts being replaced with EE watts.<br><br>High bay fixtures will have fixture efficiencies of 85% or greater.<br><br>RWT8: in order for this characterization to apply, new 4' and U-tube lamps must be listed on the CEE website on the qualifying Reduced Wattage High Performance T8 lamps list. (http://www.cee1.org/com/com-lt-main.php3).   2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table. |

DEFINITION OF BASELINE EQUIPMENT

The definition of baseline equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| The baseline is standard efficiency T8 systems that would have been installed.  The baseline for high-bay fixtures is pulse start metal halide fixtures, the baseline for a 2 lamp high efficiency troffer is a 3 lamp standard efficency troffer. | The baseline is the existing system. For T12 systems, the baseline becomes standard T8 in 2016 regardless of the equipment on site due to the phase in of EISA standards. |

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of efficient equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| Fixture lifetime is 15 years[352]. <br><br> Fixture retrofits which utilize RWT8 lamps have a lifetime equivalent to the life of the lamp, capped at 15 years.  There is no guarantee that a reduced wattage lamp will be installed at time of burnout, but if one is, savings will be captured in the RWT8 measure below. <br><br> RWT8 lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year – see reference table "RWT8 Component Costs and Lifetime"), capped at 15 years.[353] <br><br> . | Due to new federal standards for linear fluorescent lamps, manufacturers of T12 lamps will not be permitted to manufacture most varieties of T12 lamps for sale in the United States after July 2012. All remaining stock and previously manufactured product may be sold after the July 2012 effective date. If a customer relamps an existing T12 fixture the day the standard takes effect, an assumption can be made that they would likely need to upgrade to, at a minimum, 800-series T8s in less than 5 years' time. This assumes the T12s installed have a typical rated life of 20,000 hours and are operated for 4500 hours annually (average miscellaneous hours 4576/year). Certainly, it is not realistic that everyone would wait until the final moment to relamp with T12s. Also, the exempted T12 lamps greater than 87 CRI will continue to be available to purchase, although they will be expensive. Therefore the more likely scenario would be a gradual shift to T8s over the 4 year timeframe. In other words, we can expect that for each year between 2012 and 2016, ~20% of the existing T12 lighting will change over to T8 lamps that comply with the federal standard. To simplify this assumption, we recommend assuming that standard T8s become the baseline for all T12 linear fluorescent retrofit  January 1, 2016.  There will be a baseline shift applied to all measures installed before 2016. See table C-1. |

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[352] 15 years from GDS Measure Life Report, June 2007
[353] ibid

**DEEMED MEASURE COST AND O&M COST ADJUSTMENTS**

The deemed lfetime of efficient equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| Refer to reference tables A-1: Time of Sale New and Baseline Assumptions and B-1 Time of Sale T8 Component Costs and Lifetime.<br>For RTW8 refer to reference table A-3: RWT8 New and Baseline Assumptions and B-3 RWT8 T8 Component Costs and Lifetime. | Refer to reference tables A-2: Retrofit New and Baseline Assumptions and B-2 Retrofit HPT8 Component Costs and Lifetime.<br>For RTW8 refer to reference table A-3: RWT8 New and Baseline Assumptions and B-3 RWT8 T8 Component Costs and Lifetime.<br>For T12 Baseline Adjustment Factors, refer to Table C-1. |

**LOADSHAPE**

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = (\ (Watts_{base} - Watts_{EE})/1000)\ *\ Hours\ *WHF_e*ISR$$

**SUMMER COINCIDENT DEMAND SAVINGS**

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

Where:

Watts$_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

| Program | Reference Table |
|---|---|
| Time of Sale | A-1: HPT8 New and Baseline Assumptions |
| Retrofit | A-2: HPT8 New and Baseline Assumptions |
| Reduced Wattage T8, time of sale or retrofit | A-3: RWT8 New and Baseline Assumptions |

Watts$_{EE}$ = New Input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

| Program | Reference Table |
|---|---|
| Time of Sale | A-1: HPT8 New and Baseline Assumptions |
| Retrofit | A-2: HPT8 New and Baseline Assumptions |
| Reduced Wattage T8, time of sale or retrofit | A-3: RWT8 New and Baseline Assumptions |

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 6.4, Fixture annual operating hours. If hours or building type are unknown, use the Miscellaneous value.

WHF$_e$ = Waste heat factor for energy to account for cooling energy savings from efficient lighting is selected from the Reference Table in Section 6.4 for each building type. If building is un-cooled, the value is 1.0.

WHF$_d$ = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table Section 6.4 for each building type. If the building is not cooled WHFd is 1.

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%[354] if application form completed with sign off that equipment is not placed into storage

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[354]Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

If sign off form not completed assume the following 3 year ISR assumptions:

| Weigted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|
| 69.5%[355] | 15.4% | 13.1% | 98.0%[356] |

CF= Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 6.4 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

**NATURAL GAS ENERGY SAVINGS**

$\Delta Therms^{357}$ = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration 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. Please select from the Reference Table in Section 6.43 for each building type.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[355] 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption. Note these evaluations did not look at C&I specific installations but until a more appropriate C&I evaluation is performed, the Residential assumptions are applied.

[356] The 98% Lifetime ISR assumption is based upon review of two evaluations:

'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[357] Negative value because this is an increase in heating consumption due to the efficient lighting.

**DEEMED O&M COST ADJUSTMENT CALCULATION**

See Reference tables for Operating and Maintenance Values

| Program | Reference Table |
|---|---|
| Time of Sale | B-1:  HPT8 Component Costs and Lifetime |
| Retrofit | B-2:  HPT8 Component Costs and Lifetime |
| Reduced Wattage T8, time of sale or retrofit | B-3:  HPT8 Component Costs and Lifetime |

**REFERENCE TABLES**

See following page

A-1:  Time of Sale:  HPT8 New and Baseline Assumptions[358]

| EE Measure Description | Watts$_{EE}$ | Baseline Description | Watts$_{BASE}$ | Measure Cost | Watts$_{SAVE}$ |
|---|---|---|---|---|---|
| 4-Lamp HPT8 w/ High-BF Ballast High-Bay | 146 | 200 Watt Pulse Start Metal-Halide | 232 | $75 | 86 |
| 6-Lamp HPT8 w/ High-BF Ballast High-Bay | 221 | 320 Watt Pulse Start Metal-Halide | 350 | $75 | 129 |
| 8-Lamp HPT8 w/ High-BF Ballast High-Bay | 280 | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH | 455 | $75 | 175 |
| | | | | | |
| 1-Lamp HPT8-high performance 32 w lamp | 25 | 1-Lamp Standard F32T8 w/ Elec. Ballast | 32 | $15 | 7 |
| 1-Lamp HPT8-high performance 28 w lamp | 22 | 1-Lamp Standard F32T8 w/ Elec. Ballast | 32 | $15 | 10 |
| 1-Lamp HPT8-high performance 25 w lamp | 19 | 1-Lamp Standard F32T8 w/ Elec. Ballast | 32 | $15 | 13 |
| 2-Lamp HPT8 -high performance 32 w lamp | 49 | 2-Lamp Standard F32T8 w/ Elec. Ballast | 59 | $18 | 10 |
| 2-Lamp HPT8-high performance 28 w lamp | 43 | 2-Lamp Standard F32T8 w/ Elec. Ballast | 59 | $18 | 16 |
| 2-Lamp HPT8-high performance 25 w lamp | 35 | 2-Lamp Standard F32T8 w/ Elec. Ballast | 59 | $18 | 24 |
| 3-Lamp HPT8-high performance 32 w lamp | 72 | 3-Lamp Standard F32T8 w/ Elec. Ballast | 88 | $20 | 16 |
| 3-Lamp HPT8-high performance 28 w lamp | 65 | 3-Lamp Standard F32T8 w/ Elec. Ballast | 88 | $20 | 23 |
| 3-Lamp HPT8-high performance 25 w lamp | 58 | 3-Lamp Standard F32T8 w/ Elec. Ballast | 88 | $20 | 30 |
| 4-Lamp HPT8 -high performance 32 w lamp | 94 | 4-Lamp Standard F32T8 w/ Elec. Ballast | 114 | $23 | 20 |
| 4-Lamp HPT8-high performance 28 w lamp | 86 | 4-Lamp Standard F32T8 w/ Elec. Ballast | 114 | $23 | 28 |
| 4-Lamp HPT8-high performance 25 w lamp | 77 | 4-Lamp Standard F32T8 w/ Elec. Ballast | 114 | $23 | 37 |
| | | | | | |
| 2-lamp High-Performance HPT8 Troffer | 49 | 3-Lamp F32T8 w/ Elec. Ballast | 88 | $100 | 39 |

Chart assumes qualifying high efficiency low ballast factor
ballast at .77 Ballast factor

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[358] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

## A-2:  Retrofit  HPT8 New and Baseline Assumptions[359] (Note see definiton for validity after 2016)

| EE Measure Description | Watts$_{EE}$ | Baseline Description | Watts$_{BASE}$ | Incremental cost | Watts$_{SAVE}$ |
|---|---|---|---|---|---|
| 4-Lamp HPT8 w/ High-BF Ballast High-Bay | 146 | 200 Watt Pulse Start Metal-Halide | 232 | $200 | 86 |
| 4-Lamp HPT8 w/ High-BF Ballast High-Bay | 146 | 250 Watt Metal Halide | 295 | $200 | 149 |
| 6-Lamp HPT8 w/ High-BF Ballast High-Bay | 206 | 320 Watt Pulse Start Metal-Halide | 350 | $225 | 144 |
| 6-Lamp HPT8 w/ High-BF Ballast High-Bay | 206 | 400 Watt Metal Halide | 455 | $225 | 249 |
| 8-Lamp HPT8 w/ High-BF Ballast High-Bay | 280 | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH | 476 | $250 | 196 |
| 8-Lamp HPT8 w/ High-BF Ballast High-Bay | 280 | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal halide | 618 | $250 | 338 |
| 1-Lamp Relamp/Reballast T12 to HPT8 | 25 | 1-Lamp F34T12 w/ EEMag Ballast | 40 | $50 | 15 |
| 2-Lamp Relamp/Reballast T12 to HPT8 | 49 | 2-Lamp F34T12 w/ EEMag Ballast | 68 | $55 | 19 |
| 3-Lamp Relamp/Reballast T12 to HPT8 | 72 | 3-Lamp F34T12 w/ EEMag Ballast | 110 | $60 | 38 |
| 4-Lamp Relamp/Reballast T12 to HPT8 | 94 | 4-Lamp F34T12 w/ EEMag Ballast | 139 | $65 | 45 |
| 1-Lamp Relamp/Reballast T12 to HPT8 | 25 | 1-Lamp F40T12 w/ EEMag Ballast | 48 | $50 | 23 |
| 2-Lamp Relamp/Reballast T12 to HPT8 | 49 | 2-Lamp F40T12 w/ EEMag Ballast | 82 | $55 | 33 |
| 3-Lamp Relamp/Reballast T12 to HPT8 | 72 | 3-Lamp F40T12 w/ EEMag Ballast | 122 | $60 | 50 |
| 4-Lamp Relamp/Reballast T12 to HPT8 | 94 | 4-Lamp F40T12 w/ EEMag Ballast | 164 | $65 | 70 |
| 1-Lamp Relamp/Reballast T12 to HPT8 | 25 | 1-Lamp F40T12 w/ Mag Ballast | 57 | $50 | 32 |
| 2-Lamp Relamp/Reballast T12 to HPT8 | 49 | 2-Lamp F40T12 w/ Mag Ballast | 94 | $55 | 45 |
| 3-Lamp Relamp/Reballast T12 to HPT8 | 72 | 3-Lamp F40T12 w/ Mag Ballast | 147 | $60 | 75 |
| 4-Lamp Relamp/Reballast T12 to HPT8 | 94 | 4-Lamp F40T12 w/ Mag Ballast | 182 | $65 | 88 |
| 1-Lamp Relamp/Reballast T8 to HPT8 | 25 | 1-Lamp F32T8 w/ Elec. Ballast | 32 | $50 | 7 |
| 2-Lamp Relamp/Reballast T8 to HPT8 | 49 | 2-Lamp F32T8 w/ Elec. Ballast | 59 | $55 | 10 |
| 3-Lamp Relamp/Reballast T8 to HPT8 | 72 | 3-Lamp F32T8 w/ Elec. Ballast | 88 | $60 | 16 |
| 4-Lamp Relamp/Reballast T8 to HPT8 | 94 | 4-Lamp F32T8 w/ Elec. Ballast | 114 | $65 | 20 |
| 2-lamp High-Performance HPT8 Troffer or high efficiency retrofit troffer | 49 | 3-Lamp F32T8 w/ Elec. Ballast | 88 | $100 | 39 |

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[359]Ibid.

A– 3:  RWT8 New and Baseline Assumptions

| EE Measure Description | EE Cost | System WattsEE | Baseline Description | Base Cost | System Watts Base | Measure Cost | WattsSAVE |
|---|---|---|---|---|---|---|---|
| RWT8 - F28T8 Lamp | $4.50 | 25 | F32T8 Standard Lamp | $2.50 | 28 | $2.00 | 4 |
| RWT8 - F28T8 Extra Life Lamp | $4.50 | 25 | F32T8 Standard Lamp | $2.50 | 28 | $2.00 | 4 |
| RWT8 - F32/25W T8 Lamp | $4.50 | 22 | F32T8 Standard Lamp | $2.50 | 28 | $2.00 | 6 |
| RWT8 - F32/25W T8 Lamp Extra Life | $4.50 | 22 | F32T8 Standard Lamp | $2.50 | 28 | $2.00 | 6 |
| RWT8 - F17T8 Lamp - 2 Foot | $4.80 | 14 | F17T8 Standard Lamp - 2 foot | $2.80 | 16 | $2.00 | 2 |
| RWT8 - F25T8 Lamp - 3 Foot | $5.10 | 20 | F25T8 Standard Lamp - 3 foot | $3.10 | 23 | $2.00 | 3 |
| RWT8 - F30T8 Lamp - 6" Utube | $11.31 | 26 | F32T8 Standard Utube Lamp | $9.31 | 28 | $2.00 | 2 |
| RWT8 - F29T8 Lamp - Utube | $11.31 | 26 | F32T8 Standard Utube Lamp | $9.31 | 28 | $2.00 | 3 |
| RWT8 - F96T8 Lamp - 8 Foot | $9.00 | 57 | F96T8 Standard Lamp - 8 foot | $7.00 | 62 | $2.00 | 5 |

Notes:  Wattage assumptions for Reduced-Wattage T8 based on Existing 0.88 Normal Ballast Factor.

B-1:  Time of Sale T8 Component Costs and Lifetime[360]

| EE Measure Description | EE Lamp Cost | EE Lamp Life (hrs) | EE Lamp Rep. Labor Cost per lamp | EE Ballast Cost | EE Ballast Life (hrs) | EE Ballast Rep. Labor Cost | Baseline Description | Base Lamp Cost | Base Lamp Life (hrs) | Base Lamp Rep. Labor Cost | Base Ballast Cost | Base Ballast Life (hrs) | Base Ballast Rep. Labor Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4-Lamp HPT8 w/ High-BF Ballast High-Bay | $5.00 | 24000 | $6.67 | $32.50 | 70000 | $15.00 | 200 Watt Pulse Start Metal-Halide | $21.00 | 10000 | $6.67 | $88 | 40000 | $22.50 |
| 6-Lamp HPT8 w/ High-BF Ballast High-Bay | $5.00 | 24000 | $6.67 | $32.50 | 70000 | $15.00 | 320 Watt Pulse Start Metal-Halide | $21.00 | 20000 | $6.67 | $109 | 40000 | $22.50 |
| 8-Lamp HPT8 w/ High-BF Ballast High-Bay | $5.00 | 24000 | $6.67 | $32.50 | 70000 | $15.00 | Lamp HPT8 Equivalent to 320 PSMH | $21.00 | 20000 | $6.67 | $109 | 40000 | $22.50 |
| | | | | | | | | | | | | | |
| 1-Lamp HPT8 - all qualifying lamps | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 1-Lamp Standard F32T8 w/ Elec. Ballast | $2.50 | 20000 | $2.67 | $15 | 70000 | $15.00 |
| 2-Lamp HPT8 - all qualifying lamps | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 2-Lamp Standard F32T8 w/ Elec. Ballast | $2.50 | 20000 | $2.67 | $15 | 70000 | $15.00 |
| 3-Lamp HPT8 - all qualifying lamps | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 3-Lamp Standard F32T8 w/ Elec. Ballast | $2.50 | 20000 | $2.67 | $15 | 70000 | $15.00 |
| 4-Lamp HPT8 - all qualifying lamps | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 4-Lamp Standard F32T8 w/ Elec. Ballast | $2.50 | 20000 | $2.67 | $15 | 70000 | $15.00 |
| | | | | | | | | | | | | | |
| 2-lamp High-Performance HPT8 Troffer | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 3-Lamp F32T8 w/ Elec. Ballast | $2.50 | 20000 | $2.67 | $15 | 70000 | $15.00 |

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[360] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

-2:  T8 Retrofit Component Costs and Lifetime[361]

| EE Measure Description | EE Lamp Cost | EE Lamp Life (hrs) | EE Lamp Rep. Labor Cost per lamp | EE Ballast Cost | EE Ballast Life (hrs) | EE Ballast Rep. Labor Cost | Baseline Description | Base Lamp Cost | Base Lamp Life (hrs) | Base Lamp Rep. Labor Cost | Base Ballast Cost | Base Ballast Life (hrs) | Base Ballast Rep. Labor Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4-Lamp HPT8 w/ High-BF Ballast High-Bay | $5.00 | 24000 | $6.67 | $32.50 | 70000 | $15.00 | 200 Watt Pulse Start Metal-Halide | $29.00 | 12000 | $6.67 | $88 | 40000 | $22.50 |
| | | | | | | | 250 Watt Metal Halide | $21.00 | 10000 | $6.67 | $92 | 40000 | $22.50 |
| 6-Lamp HPT8 w/ High-BF Ballast High-Bay | $5.00 | 24000 | $6.67 | $32.50 | 70000 | $15.00 | 320 Watt Pulse Start Metal-Halide | $72.00 | 20000 | $6.67 | $109 | 40000 | $22.50 |
| | | | | | | | 400 Watt Metal Halide | $17.00 | 20000 | $6.67 | $114 | 40000 | $22.50 |
| 8-Lamp HPT8 w/ High-BF Ballast High-Bay | $5.00 | 24000 | $6.67 | $32.50 | 70000 | $15.00 | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH | $72.00 | 20000 | $6.67 | $109 | 40000 | $22.50 |
| | | | | | | | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 Watt Metal Halide | $17.00 | 20000 | $6.67 | $114 | 40000 | $22.50 |
| 1-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballst combinations) | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 1-Lamp T12 all lamp/ballast combinations | $2.70 | 20000 | $2.67 | $20 | 40000 | $15.00 |
| 2-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations) | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 2-Lamp T12 all lamp/ballast combinations | $2.70 | 20000 | $2.67 | $20 | 40000 | $15.00 |
| 3-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations) | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 3-Lamp T12 all lamp/ballast combinations | $2.70 | 20000 | $2.67 | $20 | 40000 | $15.00 |
| 4-Lamp Relamp/Reballast T12 to HPT8 (all lamp/ballast combinations) | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 3-Lamp T12 all lamp/ballast combinations | $2.70 | 20000 | $2.67 | $20 | 40000 | $15.00 |
| 1-Lamp Relamp/Reballast T8 to HPT8 | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 1-Lamp F32T8 w/ Elec. Ballast | $2.70 | 20000 | $2.67 | $20 | 70000 | $15.00 |
| 2-Lamp Relamp/Reballast T8 to HPT8 | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 2-Lamp F32T8 w/ Elec. Ballast | $2.70 | 20000 | $2.67 | $20 | 70000 | $15.00 |
| 3-Lamp Relamp/Reballast T8 to HPT8 | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 3-Lamp F32T8 w/ Elec. Ballast | $2.70 | 20000 | $2.67 | $20 | 70000 | $15.00 |
| 4-Lamp Relamp/Reballast T8 to HPT8 | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 4-Lamp F32T8 w/ Elec. Ballast | $2.70 | 20000 | $2.67 | $20 | 70000 | $15.00 |
| 2-lamp High-Performance HPT8 Troffer or high efficiency retrofit reflective troffer | $5.00 | 24000 | $2.67 | $32.50 | 70000 | $15.00 | 3-Lamp F32T8 w/ Elec. Ballast | $2.50 | 20000 | $2.67 | $15 | 70000 | $15.00 |

[361] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011
EPE Program Downloads.  Web accessed http://www.epelectricefficiency.com/downloads.asp?section=ci  download Copy of LSF_2012_v4.04_250rows.xls.
Kuiken et al, Focus on Energy Evaluation. Business Programs:  Deemed Savings Manual v1.0, Kema, march 22, 2010 available at
http://www.focusonenergy.com/files/Document_Management_System/Evaluation/bpdeemedsavingsmanuav10_evaluationreport.pdf

B-3: Reduced Wattage T8 Component Costs and Lifetime[362]

| EE Measure Description | EE Lamp Cost | EE Lamp Life (hrs) | Baseline Description | Base Lamp Cost | Base Lamp Life (hrs) | Base Lamp Rep. Labor Cost |
|---|---|---|---|---|---|---|
| RWT8 - F28T8 Lamp | $4.50 | 30000 | F32T8 Standard Lamp | $2.50 | 15000 | $2.67 |
| RWT8 - F28T8 Extra Life Lamp | $4.50 | 36000 | F32T8 Standard Lamp | $2.50 | 15000 | $2.67 |
| RWT8 - F32/25W T8 Lamp | $4.50 | 30000 | F32T8 Standard Lamp | $2.50 | 15000 | $2.67 |
| RWT8 - F32/25W T8 Lamp Extra Life | $4.50 | 36000 | F32T8 Standard Lamp | $2.50 | 15000 | $2.67 |
| RWT8 - F17T8 Lamp - 2 Foot | $4.80 | 18000 | F17T8 Standard Lamp - 2 foot | $2.80 | 15000 | $2.67 |
| RWT8 - F25T8 Lamp - 3 Foot | $5.10 | 18000 | F25T8 Standard Lamp - 3 foot | $3.10 | 15000 | $2.67 |
| RWT8 - F30T8 Lamp - 6" Utube | $11.31 | 24000 | F32T8 Standard Utube Lamp | $9.31 | 15000 | $2.67 |
| RWT8 - F29T8 Lamp - Utube | $11.31 | 24000 | F32T8 Standard Utube Lamp | $9.31 | 15000 | $2.67 |
| RWT8 - F96T8 Lamp - 8 Foot | $9.00 | 24000 | F96T8 Standard Lamp - 8 foot | $7.00 | 15000 | $2.67 |

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[362] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, January 2012.

C-1: T12 Baseline Adjustment:

For measures installed in 2012 through 2015, the full savings (as calculated above in the Algorithm section) will be claimed through 2015.  A savings adjustment will be applied to the annual savings for the remainder of the measure life.  The adjustment to be applied for each measure is listed in the reference table below.

Savings Adjustment Factors

| EE Measure Description | Savings Adjustment T12 EEmag ballast and 34 w lamps to HPT8 | Savings Adjustment T12 EEmag ballast and 40 w lamps to HPT8 | Savings Adjustment T12 mag ballast and 40 w lamps to HPT8 |
|---|---|---|---|
| 1-Lamp Relamp/Reballast T12 to HPT8 | 47% | 30% | 20% |
| 2-Lamp Relamp/Reballast T12 to HPT8 | 53% | 30% | 22% |
| 3-Lamp Relamp/Reballast T12 to HPT8 | 42% | 38% | 21% |
| 4-Lamp Relamp/Reballast T12 to HPT8 | 44% | 29% | 23% |

Measures installed in 2012 will claim full savings for four years, 2013 for three years, 2014 two years and 2015 one year.  Savings adjustment factors will be applied to the full savings for savings starting in 2016 and for the remainder of the measure life.  The savings adjustment is equal to the ratio between wattage reduction from T8 baseline to HPT8 and wattage reduction from T12 EE ballast with 40 w lamp baseline from the table 'T8 New and Baseline Assumptions'.[363]

Example:  2 lamp T8 to 2 lamp HPT8 retrofit saves 10 watts, while the T12 EE with 40 w lamp to HPT8 saves 33 watts. Thus the ratio of wattage reduced is 30%.  Thus the ratio of wattage reduced is 30%.

**MEASURE CODE: CI-LTG-T8FX-V01-060112**

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[363] Adapted from EVT Technical Resource Manual, 2012-75, page 85.

## 6.5.4   T5 Fixtures and Lamps

### DESCRIPTION

T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or an existing T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts.

This measure applies to the installation of new equipment with efficiencies that exceed that of the equipment that would have been installed following standard market practices and is applicable to time of sale as well as retrofit measures.

This measure was developed to be applicable to the following program types: TOS, RF.
If applied to other program types, the measure savings should be verified.
The measure applies to all commercial T5 installations excluding new construction and substantial renovation or change of use measures (see lighting power density measure).  Lookup tables have been provided to account for various installations. Actual existing equipment wattages should be compared to new fixture wattages whenever possible while maintaining lumen equivalent designs.  Default new and baseline assumptions are provided if existing equipment cannot be determined.  Actual costs and hours of use should be utilized when available. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. Configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| This program applies to installations where customer and location of equipment is not known, or at time of burnout of existing equipment. T5 Lamp/ballast systems have higher lumens per watt than a standard T8 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 fixtures, while using fewer watts. | For installations that upgrade installations before the end of their useful life.  T5 Lamp/ballast systems have higher lumens per watt than a standard T8 or T12 system. The smaller lamp diameter allows for better optical systems, and more precise control of lighting. These characteristics result in light fixtures that produce equal or greater light than standard T8 or T12 fixtures, while using fewer watts and having longer life. |

### DEFINITION OF EFFICIENT EQUIPMENT

The definition of efficient equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| 4' fixtures must use a T5 lamp and ballast configuration. 1' and 3' lamps are not eligible.  High Performance Troffers must be 85% efficient or greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better. | 4' fixtures must use a T5 lamp and ballast configuration. 1' and 3' lamps are not eligible.  High Performance Troffers must be 85% efficient or greater. T5 HO high bay fixtures must be 3, 4 or 6 lamps and 90% efficient or better. |

**DEFINITION OF BASELINE EQUIPMENT**

The definition of baseline equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| The baseline is T8 with equivalent lumen output. In high-bay applications, the baseline is pulse start metal halide systems. | The baseline is the existing system. For T12 systems, the baseline becomes standard T8 in 2016.<br><br>Retrofits to T12 systems installed before 2016 have a baseline adjustment applied in 2016 for the remainder of the measure life.<br><br><br>Due to new federal standards for linear fluorescent lamps, manufacturers of T12 lamps will not be permitted to manufacture most varieties of T12 lamps for sale in the United States after July 2012. All remaining stock and previously manufactured product may be sold after the July 2012 effective date. If a customer relamps an existing T12 fixture the day the standard takes effect, an assumption can be made that they would likely need to upgrade to, at a minimum, 800-series T8s in less than 5 years' time. This assumes the T12s installed have a typical rated life of 20,000 hours and are operated for 4500 hours annually (average miscellaneous hours 4576/year). Certainly, it is not realistic that everyone would wait until the final moment to relamp with T12s. Also, the exempted T12 lamps greater than 87 CRI will continue to be available to purchase, although they will be expensive. Therefore the more likely scenario would be a gradual shift to T8s over the 4 year timeframe. In other words, we can expect that for each year between 2012 and 2016, ~20% of the existing T12 lighting will change over to T8 lamps that comply with the federal standard. To simplify this assumption, we recommend assuming that standard T8s become the baseline for all T12 linear fluorescent retrofit January 1, 2016. There will be a baseline shift applied to all measures installed before 2016 in 2016 in years remaining in the measure life.. See table C-1. |

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of the efficient equipment fixture, regardless of program type is Fixture lifetime is 15 years[364].

### DEEMED MEASURE COST AND O&M COST ADJUSTMENTS

The deemed lifetime of efficient equipment varies based on the program and is defined below:

| Time of Sale (TOS) | Retrofit (RF) |
|---|---|
| Refer to reference tables A-1: Time of Sale New and Baseline Assumptions and B-1: Time of Sale T5 Component Costs and Lifetime. | Refer to reference tables A-2: Retrofit New and Baseline Assumptions and B-2 Retrofit T5 Component Costs and Life. |

### LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

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### Algorithm

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### CALCULATION OF SAVINGS

### ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ( (Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

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[364] 15 years from GDS Measure Life Report, June 2007

**SUMMER COINCIDENT DEMAND SAVINGS**

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

Where:

| Program | Reference Table |
|---|---|
| Time of Sale | A-1: T5 New and Baseline Assumptions |
| Retrofit | A-2: T5 New and Baseline Assumptions |

$Watts_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

$Watts_{EE}$ = New Input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

| Program | Reference Table |
|---|---|
| Time of Sale | A-1: T5 New and Baseline Assumptions |
| Retrofit | A-2: T5 New and Baseline Assumptions |

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 6.4, Fixture annual operating hours, by building type. If hours or building type are unknown, use the Miscellaneous value.

$WHF_e$ = Waste heat factor for energy to account for cooling energy savings from efficient lighting is selected from the Reference Table in Section 6.4 for each building type. If building is un-cooled, the value is 1.0.

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 6.4 for each building type. If the building is not cooled WHFd is 1.

ISR = = In Service Rate or the percentage of units rebated that get installed.

=100%[365] if application form completed with sign off that equipment is not placed into storage

If sign off form not completed assume the following 3 year ISR assumptions:

| Weigted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|
| 69.5%[366] | 15.4% | 13.1% | 98.0%[367] |

CF= Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 6.4 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

**NATURAL GAS ENERGY SAVINGS**

$\Delta$Therms[368] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration 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. This value is selected from the Reference Table in Section 6.4 for each building type.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[365]Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

[366] 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption. Note these evaluations did not look at C&I specific installations but until a more appropriate C&I evaluation is performed, the Residential assumptions are applied.

[367] The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[368]Negative value because this is an increase in heating consumption due to the efficient lighting.

**DEEMED O&M COST ADJUSTMENT CALCULATION**

See Reference tables for Operating and Maintenance Values

| Program | Reference Table |
|---|---|
| Time of Sale | B-1:  T5 Component Costs and Lifetime |
| Retrofit | B-2:  T5 Component Costs and Lifetime |

**REFERENCE TABLES**

See following page

A-1: Time of Sale: T5 New and Baseline Assumptions[369]

| EE Measure Description | EE Cost | Watts$_{EE}$ | Baseline Description | Base Cost | Watts$_{BASE}$ | Measure Cost | Watts$_{SAVE}$ |
|---|---|---|---|---|---|---|---|
| 2-Lamp T5 High-Bay | $200.00 | 180 | 200 Watt Pulse Start Metal-Halide | $100.00 | 232 | $100.00 | 52 |
| 3-Lamp T5 High-Bay | $200.00 | 180 | 200 Watt Pulse Start Metal-Halide | $100.00 | 232 | $100.00 | 52 |
| 4-Lamp T5 High-Bay | $225.00 | 240 | 320 Watt Pulse Start Metal-Halide | $125.00 | 350 | $100.00 | 110 |
| 6-Lamp T5 High-Bay | $250.00 | 360 | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH | $150.00 | 476 | $100.00 | 116 |
| | | | | | | | |
| 1-Lamp T5 Troffer/Wrap | $100.00 | 32 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | $60.00 | 44 | $40.00 | 12 |
| 2-Lamp T5 Troffer/Wrap | $100.00 | 64 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | $60.00 | 88 | $40.00 | 24 |
| | | | | | | | |
| 1-Lamp T5 Industrial/Strip | $70.00 | 32 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | $40.00 | 44 | $30.00 | 12 |
| 2-Lamp T5 Industrial/Strip | $70.00 | 64 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | $40.00 | 88 | $30.00 | 24 |
| 3-Lamp T5 Industrial/Strip | $70.00 | 96 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | $40.00 | 132 | $30.00 | 36 |
| 4-Lamp T5 Industrial/Strip | $70.00 | 128 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | $40.00 | 178 | $30.00 | 50 |
| | | | | | | | |
| 1-Lamp T5 Indirect | $175.00 | 32 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | $145.00 | 44 | $30.00 | 12 |
| 2-Lamp T5 Indirect | $175.00 | 64 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | $145.00 | 88 | $30.00 | 24 |

[369] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

A-2: Retrofit T5 New and Baseline Assumptions[370]

| EE Measure Description | EE Cost | Watts$_{EE}$ | Baseline Description | Watts$_{BASE}$ |
|---|---|---|---|---|
| 3-Lamp T5 High-Bay | $ 200 | 180 | 200 Watt Pulse Start Metal-Halide | 232 |
| 4-Lamp T5 High-Bay | $ 225 | 240 | 250 Watt Metal-Halide | 295 |
| 6-Lamp T5 High-Bay | $ 250 | 360 | 320 Watt Pulse Start Metal-Halide | 350 |
| | | | 400 Watt Metal halide | 455 |
| 1-Lamp T5 Troffer/Wrap | $ 100 | 32 | 400 Watt Pulse Start Metal-halide | 476 |
| 2-Lamp T5 Troffer/Wrap | $ 100 | 64 | | |
| | | | 1-Lamp F34T12 w/ EEMag Ballast | 40 |
| 1-Lamp T5 Industrial/Strip | $ 70 | 32 | 2-Lamp F34T12 w/ EEMag Ballast | 68 |
| 2-Lamp T5 Industrial/Strip | $ 70 | 64 | 3-Lamp F34T12 w/ EEMag Ballast | 110 |
| 3-Lamp T5 Industrial/Strip | $ 70 | 96 | 4-Lamp F34T12 w/ EEMag Ballast | 139 |
| 4-Lamp T5 Industrial/Strip | $ 70 | 128 | | |
| | | | 1-Lamp F40T12 w/ EEMag Ballast | 48 |
| 1-Lamp T5 Indirect | $ 175 | 32 | 2-Lamp F40T12 w/ EEMag Ballast | 82 |
| 2-Lamp T5 Indirect | $ 175 | 64 | 3-Lamp F40T12 w/ EEMag Ballast | 122 |
| | | | 4-Lamp F40T12 w/ EEMag Ballast | 164 |
| | | | | |
| | | | 1-Lamp F40T12 w/ Mag Ballast | 57 |
| | | | 2-Lamp F40T12 w/ Mag Ballast | 94 |
| | | | 3-Lamp F40T12 w/ Mag Ballast | 147 |
| | | | 4-Lamp F40T12 w/ Mag Ballast | 182 |
| | | | | |
| | | | 1-Lamp F32 T8 | 32 |
| | | | 2-Lamp F32 T8 | 59 |
| | | | 3-Lamp F32 T18 | 88 |
| | | | 4-Lamp F32 T8 | 114 |

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[370]Ibid.

## B-1: Time of Sale T5 Component Costs and Lifetime[371]

| EE Measure Description | EE Lamp Cost | EE Lamp Life (hrs) | EE Lamp Rep. Labor Cost per lamp | EE Ballast Cost | EE Ballast Life (hrs) | EE Ballast Rep. Labor Cost | Baseline Description | # Base Lamps | Base Lamp Cost | Base Lamp Life (hrs) | Base Lamp Rep. Labor Cost | # Base Ballasts | Base Ballast Cost | Base Ballast Life (hrs) | Base Ballast Rep. Labor Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-Lamp T5 High-Bay | $12.00 | 20000 | $6.67 | $52.00 | 70000 | $22.50 | 200 Watt Pulse Start Metal-Halide | 1.00 | $21.00 | 10000 | $6.67 | 1.00 | $87.75 | 40000 | $22.50 |
| 4-Lamp T5 High-Bay | $12.00 | 20000 | $6.67 | $52.00 | 70000 | $22.50 | 320 Watt Pulse Start Metal-Halide | 1.00 | $21.00 | 20000 | $6.67 | 1.00 | $109.35 | 40000 | $22.50 |
| 6-Lamp T5 High-Bay | $12.00 | 20000 | $6.67 | $52.00 | 70000 | $22.50 | Adjusted according to 6-Lamp HPT8 Equivalent to 320 | 1.36 | $21.00 | 20000 | $6.67 | 1.50 | $109.35 | 40000 | $22.50 |
| 1-Lamp T5 Troffer/Wrap | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 1.50 | $2.50 | 20000 | $2.67 | 0.50 | $15.00 | 70000 | $15.00 |
| 2-Lamp T5 Troffer/Wrap | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | 3.00 | $2.50 | 20000 | $2.67 | 1.00 | $15.00 | 70000 | $15.00 |
| 1-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 1.50 | $2.50 | 20000 | $2.67 | 0.50 | $15.00 | 70000 | $15.00 |
| 2-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | 3.00 | $2.50 | 20000 | $2.67 | 1.00 | $15.00 | 70000 | $15.00 |
| 3-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent | 4.50 | $2.50 | 20000 | $2.67 | 1.50 | $15.00 | 70000 | $15.00 |
| 4-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 6.00 | $2.50 | 20000 | $2.67 | 2.00 | $15.00 | 70000 | $15.00 |
| 1-Lamp T5 Indirect | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 1.50 | $2.50 | 20000 | $2.67 | 0.50 | $15.00 | 70000 | $15.00 |
| 2-Lamp T5 Indirect | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | 3.00 | $2.50 | 20000 | $2.67 | 1.00 | $15.00 | 70000 | $15.00 |

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[371] Adapted from Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011.

# B-2: T5 Retrofit Component Costs and Lifetime[372]

| EE Measure Description | EE Lamp Cost | EE Lamp Life (hrs) | EE Lamp Rep. Labor Cost per lamp | EE Ballast Cost | EE Ballast Life (hrs) | EE Ballast Rep. Labor Cost | Baseline Description | # Base Lamps | Base Lamp Cost | Base Lamp Life (hrs) | Base Lamp Rep. Labor Cost | # Base Ballasts | Base Ballast Cost | Base Ballast Life (hrs) | Base Ballast Rep. Labor Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-Lamp T5 High-Bay | $12.00 | 20000 | $6.67 | $52.00 | 70000 | $22.50 | 200 Watt Pulse Start Metal-Halide | 1.00 | $21.00 | 10000 | $6.67 | 1.00 | $ 88 | 40000 | $22.50 |
|  |  |  |  |  |  |  | 250 Watt Metal Halide | 1.00 | $21.00 | 10000 | $6.67 | 1.00 | $ 92 | 40000 | $22.50 |
| 4-Lamp T5 High-Bay | $12.00 | 20000 | $6.67 | $52.00 | 70000 | $22.50 | 320 Watt Pulse Start Metal-Halide | 1.00 | $72.00 | 20000 | $6.67 | 1.00 | $ 109 | 40000 | $22.50 |
|  |  |  |  |  |  |  | 400 Watt Metal Halide | 1.00 | $17.00 | 20000 | $6.67 | 1.00 | $ 114 | 40000 | $22.50 |
| 6-Lamp T5 High-Bay | $12.00 | 20000 | $6.67 | $52.00 | 70000 | $22.50 | Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH | 1.36 | $72.00 | 20000 | $6.67 | 1.50 | $ 109 | 40000 | $22.50 |
| 1-Lamp T5 Troffer/Wrap | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 1.50 | $2.50 | 20000 | $2.67 | 0.50 | $ 15 | 70000 | $15.00 |
| 2-Lamp T5 Troffer/Wrap | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | 3.00 | $2.50 | 20000 | $2.67 | 1.00 | $ 15 | 70000 | $15.00 |
| 1-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 1.50 | $2.50 | 20000 | $2.67 | 0.50 | $ 15 | 70000 | $15.00 |
| 2-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | 3.00 | $2.50 | 20000 | $2.67 | 1.00 | $ 15 | 70000 | $15.00 |
| 3-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 4.50 | $2.50 | 20000 | $2.67 | 1.50 | $ 15 | 70000 | $15.00 |
| 4-Lamp T5 Industrial/Strip | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 6.00 | $2.50 | 20000 | $2.67 | 2.00 | $ 15 | 70000 | $15.00 |
| 1-Lamp T5 Indirect | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | Proportionally adjusted according to 2-Lamp T5 Equivalent to 3-Lamp T8 | 1.50 | $2.50 | 20000 | $2.67 | 0.50 | $ 15 | 70000 | $15.00 |
| 2-Lamp T5 Indirect | $12.00 | 20000 | $2.67 | $52.00 | 70000 | $15.00 | 3-Lamp F32T8 Equivalent w/ Elec. Ballast | 3.00 | $2.50 | 20000 | $2.67 | 1.00 | $ 15 | 70000 | $15.00 |

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[372] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, October 26, 2011
EPE Program Downloads. Web accessed http://www.epelectricefficiency.com/downloads.asp?section=ci download Copy of LSF_2012_v4.04_250rows.xls.
Kuiken et al, Focus on Energy Evaluation. Business Programs: Deemed Savings Manual v1.0, Kema, march 22, 2010 available at
http://www.focusonenergy.com/files/Document_Management_System/Evaluation/bpdeemedsavingsmanuav10_evaluationreport.pdf

C-1:  T12 Baseline Adjustment:


Savings Adjustment Factors

| | watts | Equivalent T12 watts adjusted for lumen equivalency-34 w and 40 w with EEMag ballast | Equivalent T12 watts adjusted for lumen equivalency-40 w with EEMag ballast | Equivalent T12 watts adjusted for lumen equivalency-40 w with Mag ballast | Prportionally Adjusted for Lumens wattage for T8 equivalent |
|---|---|---|---|---|---|
| 1-Lamp T5 Industrial/Strip | 32 | 61 | 73 | 82 | 44 |
| 2-Lamp T5 Industrial/Strip | 64 | 103 | 125 | 135 | 88 |
| 3-Lamp T5 Industrial/Strip | 96 | 167 | 185 | 211 | 132 |
| 4-Lamp T5 Industrial/Strip | 128 | 211 | 249 | 226 | 178 |
| | | Savings Factor Adjustment to the T8 baseline | Savings Factor Adjustment to the T8 baseline | Savings Factor Adjustment to the T8 baseline | |
| 1-Lamp T5 Industrial/Strip | | 42% | 29% | 24% | |
| 2-Lamp T5 Industrial/Strip | | 61% | 40% | 34% | |
| 3-Lamp T5 Industrial/Strip | | 51% | 40% | 31% | |
| 4-Lamp T5 Industrial/Strip | | 60% | 41% | 51% | |

Measures installed in 2012 will claim full savings for four years, 2013 for three years, 2014 two years and 2015 one year.  Savings adjustment factors based on a T8 baseline will be applied to the full savings for savings starting in 2016 and for the remainder of the measure life. The adjustment to be applied for each measure is listed in the reference table above and is based on equivalent lumens.

MEASURE CODE: CI-LTG-T5FX-V01-060112

## 6.5.5   Occupancy Sensor Lighting Controls

DESCRIPTION

This measure relates to the installation of new occupancy sensors on a new or existing lighting system.  Lighting control types covered by this measure include wall, ceiling or fixture mounted occupancy sensors. Passive infrared, ultrasonic detectors and fixture-mounted sensors or sensors with a combination thereof are eligible.  Lighting controls required by state energy codes are not eligible.  This must be a new installation and may not replace an existing lighting occupancy sensor control.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the existing system is assumed to be manually controlled or an uncontrolled lighting system which is being controlled by one of the lighting controls systems listed above. All sensors must be hard wired and control interior lighting.

DEFINITION OF BASELINE EQUIPMENT

The baseline is assumed to be a lighting system uncontrolled by occupancy.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for all lighting controls is assumed to be 8 years[373].

DEEMED MEASURE COST

When available, the actual cost of the measure shall be used.  When not available, the following default values are provided:

| Lighting control type | Cost |
|---|---|
| Full cost of wall mounted occupancy sensor | $42[374] |
| Full cost mounted occupancy sensor | $66[375] |
| Full cost of fixture-mounted occupancy sensor | $125[376] |

DEEMED O&M COST ADJUSTMENTS

N/A

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[373] DEER 2008

[374] Goldberg et al, State of Wisconsin, Public Service Commission of Wisconsin, Focus on Energy Evaluation Business programs Incremental Cost Study, KEMA, October 28, 2009

[375] Ibid

[376] Efficiency Vermont TRM, October 26, 2011.

**LOADSHAPE**

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is dependent on location.

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = KW_{Controlled} * Hours * ESF * WHF_e \backslash \text{Summer Coincident Peak Demand Savings}$$

$$\Delta kW = KW_{controlled} * ESF * WHF_d * CF$$

Where:

$Kw_{Controlled}$ = Total lighting load connected to the control in kilowatts. Savings is per control. The total connected load per control should be collected from the customer or the default values presented below used;

| Lighting Control Type | Default kw controlled |
|---|---|
| Wall mounted occupancy sensor | 0.350[377] |
| Remote mounted occupancy sensor | 0.587[378] |
| Fixture mounted sensor | 0.073[379] |

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[377] Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs, Incremental Cost Study, KEMA, October 28, 2009

[378] Ibid

Hours = total operating hours of the controlled lighting circuit before the lighting controls are installed. This number should be collected from the customer. Average hours of use per year are provided in the Reference Table in Section 6.4, Fixture annual operating hours, for each building type if customer specific information is not collected. If unknown buidling type, use the Miscellaneous value.

ESF = Energy Savings factor (percentage of time the circuit will be off, thus saving energy

| Lighting Control Type | Energy Savings Factor[380] |
|---|---|
| Wall or Ceiling-Mounted Occupancy Sensors | 41% or custom |
| Fixture Mounted Occupancy Sensors | 30% or custom |

$WHF_e$ = Waste heat factor for energy to account for cooling energy savings from efficient lighting is provided in the Reference Table in Section 6.4 for each building type. If building is un-cooled, the value is 1.0.

$WHF_d$ = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in the Reference Table in Section 6.4. If the building is un-cooled WHFd is 1.

CF = Summer Peak Coincidence Factor for measure is 0.15 regardless of building type.[381]

**NATURAL GAS ENERGY SAVINGS**

Δtherms = ΔKWH* - IFTherms

Where:

IFTherms = Lighting-HVAC Integration 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 and provided in the Reference Table in Section 6.4 by buidling type.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-LTG-OSLC-V01-060112**

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[379] Efficiency Vermont TRM 2/19/2010

[380] Kuiken, Tammy eta al, State of Wisconsin/Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs, Deemed Savings Manual V1.0, PA Consulting Group and KEMA, March 22, 2010 pp 4-192-194.

[381] Coincidence Factor Study Residential and Commercial Industrial Lighting Measures, RLW Analytics, Spring 2007.

## 6.5.6  Lighting Power Density

**DESCRIPTION**

This measure relates to installation of efficient lighting systems in new construction or substantial renovation of commercial buildings excluding low rise (three stories or less) residential buildings.  Substantial renovation is when two or more building systems are renovated, such as shell and heating, heating and lighting, etc.  State Energy Code specifies a lighting power density level by building type for both the interior and the exterior.  Either the Building Area Method as defined in IECC 2009 or the Space-by-Space Method defined in ASHAE 90.1 2007 can be used for calculating the Interior Lighting Power Density[382].  The measure consists of a design that is more efficient (has a lower lighting power density in watts/square foot) than code requires.  The IECC 2009, which is adopted in Illinois, applies to both new construction and renovation.

This measure was developed to be applicable to the following program types: NC.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

In order for this characterization to apply, the lighting system must be more efficient than the baseline Energy Code lighting power density in watts/square foot for either the interior space or exterior space.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline is assumed to be a lighting power density that meets IECC 2009, the State of Illinois Energy Code by building type or ASHRAE 90.1 2007 Space – by- Space requirements.

**DEEMED CALCULATION FOR THIS MEASURE**

Annual kWh Savings = ΔkWh = (WSFbase-WSFeffic )/1000* SF* Hours * $WHF_e$

Summer Coincident Peak kW Savings = ΔkW = (WSFbase-WSFeffic )/1000* SF* CF * $WHF_d$

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 15 years[383]

**DEEMED MEASURE COST**

The actual incremental cost over a baseline system will be collected from the customer if possible or developed on a fixture by fixture basis.

---

[382] Refer to the referenced code documents for specifics on calculating lighting power density using either the whole building method (IECC) or the Space by Space method (ASHRAE 90.1).
[383] Measure Life Report, Residential and Commercial/Industrial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is dependent on the building type.

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

$$\Delta kWh = (WSF_{base} - WSF_{effic})/1000 * SF * Hours * WHF_e$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = (WSF_{base} - WSF_{effic})/1000 * SF * CF * WHF_d$$

Where:

$WSF_{base}$ = Baseline lighting watts per square foot or linear foot as determined by building or space type. Whole building analysis values are presented in the Reference Tables below.[384]

$WSF_{effic}$ = The actual installed lighting watts per square foot or linear foot.

---

[384]IECC 2009 - Reference Code documentation for additional information.

SF = Provided by customer based on square footage of the building area applicable to the lighting design for new building.

Hours = Annual site-specific hours of operation of the lighting equipment collected from the customer. If not available, use building area type as provided in the Reference Table in Section 6.4, Fixture annual operating hours.

$WHF_e$ = Waste Heat Factor for Energy to account for cooling savings from efficient lighting is as provided in the Reference Table in Section 6.4 by buidling type. If building is not cooled $WHF_e$ is 1.

$WHF_d$ = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is as provided in the Reference Table in Section 6.4 by buidling type. If building is not cooled WHFd is 1.

CF = Summer Peak Coincidence Factor for measure is as provided in the Reference Table in Section 5.4 by buidling type. If the building type is unknown, use the Miscellaneous value of 0.66.

## NATURAL GAS ENERGY SAVINGS

Δtherms = ΔKWH* - IFTherms

Where:

IFTherms = Lighting-HVAC Integration 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. This value is provided in the Reference Table in Section 6.4 by buidling type.

### WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

### DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

### REFERENCE TABLES

Lighting Power Density Values from IECC 2009 for Interior Commercial New Construction and Substantial Renovation

| Building Area Type [385] | Lighting Power Density (w/ft$^2$) |
|---|---|
| Automotive Facility | 0.9 |
| Convention Center | 1.2 |
| Court House | 1.2 |
| Dining: Bar Lounge/Leisure | 1.3 |

---

[385] IECC 2009 in cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.

| Building Area Type [385] | Lighting Power Density (w/ft$^2$) |
|---|---|
| Dining: Cafeteria/Fast Food | 1.4 |
| Dining: Family | 1.6 |
| Dormitory | 1.0 |
| Exercise Center | 1.0 |
| Gymnasium | 1.1 |
| Healthcare – clinic | 1.0 |
| Hospital | 1.2 |
| Hotel | 1.0 |
| Library | 1.3 |
| Manufacturing Facility | 1.3 |
| Motel | 1.0 |
| Motion Picture Theater | 1.2 |
| Multifamily | 0.7 |
| Museum | 1.1 |
| Office | 1.0 |
| Parking Garage | 0.3 |
| Penitentiary | 1.0 |
| Performing Arts Theater | 1.6 |
| Police/Fire Station | 1.0 |
| Post Office | 1.1 |
| Religious Building | 1.3 |
| Retail[386] | 1.5 |
| School/University | 1.2 |
| Sports Arena | 1.1 |
| Town Hall | 1.1 |
| Transportation | 1.0 |
| Warehouse | 0.8 |
| Workshop | 1.4 |

**REFERENCE TABLES**

The exterior lighting design will be based on the building location and the applicable "Lighting Zone" as defined in IECC 2009 Table 505.6.2(1) which follows.

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[386] Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the small of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

**TABLE 505.6.2(1)**
**EXTERIOR LIGHTING ZONES**

| LIGHTING ZONE | DESCRIPTION |
|---|---|
| 1 | Developed areas of national parks, state parks, forest land, and rural areas |
| 2 | Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas |
| 3 | All other areas |
| 4 | High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority |

The lighting power density savings will be based on reductions below the allowable design levels as specified in IECC 2009 Table 505.6.2(2) which follows.

**TABLE 505.6.2(2)**
**INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS**

| | | Zone 1 | Zone 2 | Zone 3 | Zone 4 |
|---|---|---|---|---|---|
| Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.) | | 500 W | 600 W | 750 W | 1300 W |
| Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.) | **Uncovered Parking Areas** | | | | |
| | Parking areas and drives | 0.04 W/ft² | 0.06 W/ft² | 0.10 W/ft² | 0.13 W/ft² |
| | **Building Grounds** | | | | |
| | Walkways less than 10 feet wide | 0.7 W/linear foot | 0.7 W/linear foot | 0.8 W/linear foot | 1.0 W/linear foot |
| | Walkways 10 feet wide or greater, plaza areas special feature areas | 0.14 W/ft² | 0.14 W/ft² | 0.16 W/ft² | 0.2 W/ft² |
| | Stairways | 0.75 W/ft² | 1.0 W/ft² | 1.0 W/ft² | 1.0 W/ft² |
| | Pedestrian tunnels | 0.15 W/ft² | 0.15 W/ft² | 0.2 W/ft² | 0.3 W/ft² |
| | **Building Entrances and Exits** | | | | |
| | Main entries | 20 W/linear foot of door width | 20 W/linear foot of door width | 30 W/linear foot of door width | 30 W/linear foot of door width |
| | Other doors | 20 W/linear foot of door width | 20 W/linear foot of door width | 20 W/linear foot of door width | 20 W/linear foot of door width |
| | Entry canopies | 0.25 W/ft² | 0.25 W/ft² | 0.4 W/ft² | 0.4 W/ft² |
| | **Sales Canopies** | | | | |
| | Free-standing and attached | 0.6 W/ft² | 0.6 W/ft² | 0.8 W/ft² | 1.0 W/ft² |
| | **Outdoor Sales** | | | | |
| | Open areas (including vehicle sales lots) | 0.25 W/ft² | 0.25 W/ft² | 0.5 W/ft² | 0.7 W/ft² |
| | Street frontage for vehicle sales lots in addition to "open area" allowance | No allowance | 10 W/linear foot | 10 W/linear foot | 30 W/linear foot |
| Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.) | Building facades | No allowance | 0.1 W/ft² for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length | 0.15 W/ft² for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length | 0.2 W/ft² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length |
| | Automated teller machines and night depositories | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location | 270 W per location plus 90 W per additional ATM per location |
| | Entrances and gatehouse inspection stations at guarded facilities | 0.75 W/ft² of covered and uncovered area | 0.75 W/ft² of covered and uncovered area | 0.75 W/ft² of covered and uncovered area | 0.75 W/ft² of covered and uncovered area |
| | Loading areas for law enforcement, fire, ambulance and other emergency service vehicles | 0.5 W/ft² of covered and uncovered area | 0.5 W/ft² of covered and uncovered area | 0.5 W/ft² of covered and uncovered area | 0.5 W/ft² of covered and uncovered area |
| | Drive-up windows/doors | 400 W per drive-through | 400 W per drive-through | 400 W per drive-through | 400 W per drive-through |
| | Parking near 24-hour retail entrances | 800 W per main entry | 800 W per main entry | 800 W per main entry | 800 W per main entry |

**MEASURE CODE: CI-LTG-LPDE-V01-060112**

## 6.5.7   LED Traffic and Pedestrian Signals

### DESCRIPTION

Traffic and pedestrian signals are retrofitted to be illuminated with light emitting diodes (LED) instead of incandescent lamps. Incentive applies for the replacement or retrofit of existing incandescent traffic signals with new LED traffic and pedestrian signal lamps.  Each lamp can have no more than a maximum LED module wattage of 25. Incentives are not available for spare lights. Lights must be hardwired and single lamp replacements are not eligible, with the exception of pedestrian hand signals. Eligible lamps must meet the Energy Star Traffic Signal Specification and the Institute for Transportation Engineers specification for traffic signals.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

### 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 LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of an LED traffic signal is 100,000 hours (manufacturer's estimate), capped at 10 years.[387] 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[388]

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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387 ACEEE, (1998) A Market Transformation Opportunity Assessment for LED Traffic Signals,
http://www.cee1.org/gov/led/led-ace3/ace3led.pdf
388 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

**LOADSHAPE**

Loadshape C24 - Traffic Signal - Red Balls, always changing or flashing

Loadshape C25 - Traffic Signal - Red Balls, changing day, off night

Loadshape C26 - Traffic Signal - Green Balls, always changing

Loadshape C27 - Traffic Signal - Green Balls, changing day, off night

Loadshape C28 - Traffic Signal - Red Arrows

Loadshape C29 - Traffic Signal - Green Arrows

Loadshape C30 - Traffic Signal - Flashing Yellows

Loadshape C31 - Traffic Signal - "Hand" Don't Walk Signal

Loadshape C32 - Traffic Signal - "Man" Walk Signal

Loadshape C33 - Traffic Signal - Bi-Modal Walk/Don't Walk

**COINCIDENCE FACTOR**[389]

The summer peak coincidence factor (CF) for this measure is dependent on lamp type as below:

| Lamp Type | CF |
|---|---|
| Red Round, always changing or flashing | 0.55 |
| Red Arrows | 0.90 |
| Green Arrows | 0.10 |
| Yellow Arrows | 0.03 |
| Green Round, always changing or flashing | 0.43 |
| Flashing Yellow | 0.50 |
| Yellow Round, always changing | 0.02 |
| "Hand" Don't Walk Signal | 0.75 |
| "Man" Walk Signal | 0.21 |

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = (W_{base} - W_{eff}) \times HOURS / 1000$$

Where:

Wbase = The connected load of the baseline equipment

= see Table 'Traffic Signals Technology Equivalencies'

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[389] Ibid

Weff            =The connected load of the baseline 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)

---

**EXAMPLE**

For example, an 8 inch red, round signal:

$$\Delta kWh = ((69 - 7) \times 4818) / 1000$$
$$= 299 \text{ kWh}$$

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = (W_{base} - W_{eff}) \times CF / 1000$$

Where:

Wbase          =The connected load of the baseline equipment

                       = see Table 'Traffic Signals Technology Equivalencies'

Weff            =The connected load of the efficient equipment

                       = see Table 'Traffic Signals Technology Equivalencies'

CF              = Summer Peak Coincidence Factor for measure

---

**EXAMPLE**

For example, an 8 inch red, round signal:

$$\Delta kW = ((69 - 7) \times 0.55) / 1000$$

$$= 0.0341 \text{ kW}$$

---

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**REFERENCE TABLES**

Traffic Signals Technology Equivalencies[390]

| Traffic Fixture Type | Fixture Size and Color | Efficient Lamps | Baseline Lamps | HOURS | Efficient Fixture Wattage | Baseline Fixture Wattage | Energy Savings (in kWh) |
|---|---|---|---|---|---|---|---|
| Round Signals | 8" Red | LED | Incandescent | 4818 | 7 | 69 | 299 |
| Round Signals | 12" Red | LED | Incandescent | 4818 | 6 | 150 | 694 |
| Flashing Signal[391] | 8" Red | LED | Incandescent | 4380 | 7 | 69 | 272 |
| Flashing Signal | 12" Red | LED | Incandescent | 4380 | 6 | 150 | 631 |
| Flashing Signal | 8" Yellow | LED | Incandescent | 4380 | 10 | 69 | 258 |
| Flashing Signal | 12" Yellow | LED | Incandescent | 4380 | 13 | 150 | 600 |
| Round Signals | 8" Yellow | LED | Incandescent | 175 | 10 | 69 | 10 |
| Round Signals | 12" Yellow | LED | Incandescent | 175 | 13 | 150 | 24 |
| Round Signals | 8" Green | LED | Incandescent | 3767 | 9 | 69 | 266 |
| Round Signals | 12" Green | LED | Incandescent | 3767 | 12 | 150 | 520 |
| Turn Arrows | 8" Yellow | LED | Incandescent | 701 | 7 | 116 | 76 |
| Turn Arrows | 12" Yellow | LED | Incandescent | 701 | 9 | 116 | 75 |
| Turn Arrows | 8" Green | LED | Incandescent | 701 | 7 | 116 | 76 |
| Turn Arrows | 12" Green | LED | Incandescent | 701 | 7 | 116 | 76 |
| Pedestrian Sign | 12" Hand/Man | LED | Incandescent | 8760 | 8 | 116 | 946 |

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

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[390] 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
[391] Technical Reference Manual for Ohio, August 6, 2010

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

**MEASURE CODE: CI-LTG-LEDT-V01-060112**

## 6.6 Refrigeration End Use

### 6.6.1 Automatic Door Closer for Walk-In Coolers and Freezers

**DESCRIPTION**

This measure is for installing an auto-closer to the main insulated opaque door(s) of a walk-in cooler or freezer. The auto-closer must firmly close the door when it is within 1 inch of full closure.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

This measure consists of the installation of an automatic, hydraulic-type door closer on main walk-in cooler or freezer doors. These closers save energy by reducing the infiltration of warm outside air into the refrigeration itself.

**DEFINITION OF BASELINE EQUIPMENT**

In order for this characterization to apply, the baseline condition is assumed to be a walk in cooler or freezer without an automatic closure.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The deemed measure life is 8 years.[392]

**DEEMED MEASURE COST**

The deem measure cost is $156.82 for a walk-in cooler or freezer.[393]

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C22 - Commercial Refrigeration

**COINCIDENCE FACTOR**

The measure has deemed kW savings therefore a coincidence factor does not apply

---

[392] Source: DEER 2008
[393] Ibid.

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Savings calculations are based on values from through PG&E's Workpaper PGECOREF110.1 – Auto-Closers for Main Cooler or Freezer Doors. Savings are averaged across all California climate zones and vintages[394].

| Annual Savings | kWh |
|---|---|
| Walk in Cooler | 943 kWh |
| Walk in Freezer | 2307 kWh |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

| Annual Savings | kW |
|---|---|
| Walk in Cooler | 0.137 kW |
| Walk in Freezer | 0.309 kW |

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-RFG-ATDC-V01-060112**

---

[394] Measure savings from ComEd TRM developed by KEMA. June 1, 2010

## 6.6.2   Beverage and Snack Machine Controls

**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.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

**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 LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 5 years [395].

**DEEMED MEASURE COST**

The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes[396]:

   Refrigerated Vending Machine and Glass Front Cooler: $180.00

   Non-Refrigerated Vending Machine: $80.00

**DEEMED O&M COST ADJUSTMENTS**

N/A

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[395] Measure Life Study, prepared for the Massachusetts Joint Utilities, Energy & Resource Solutions, November 2005.
[396] ComEd workpapers, 8—15-11.pdf

**LOADSHAPE**

Loadshape C52 - Beverage and Snack Machine Controls

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be $0$[397].

---

## Algorithm

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh    = WATTSbase / 1000 * HOURS * ESF

Where:

WATTSbase    = connected kW of the controlled equipment; see table below for default values by connected equipment type:

| Equipment Type | WATTSbase[398] |
|---|---|
| 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, 365.25 days per year

= 8766

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)[399] |
|---|---|
| Refrigerated Beverage Vending Machines | 46% |
| Non-Refrigerated Snack Vending Machines | 46% |
| Glass Front Refrigerated Coolers | 30% |

---

[397] Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.
[398] USA Technologies Energy Management Product Sheets, July 2006; cited September 2009. <http:// http://www.usatech.com/energy_management/energy_productsheets.php>
[399] Ibid.

**EXAMPLE**

For example, adding controls to a refrigerated beverage vending machine:

ΔkWh   = WATTSbase / 1000 * HOURS * ESF

=400/1000* 8766* .46 = 1.6 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-RFG-BEVM-V01-060112**

## 6.6.3   Door Heater Controls for Cooler or Freezer

### 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.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

### 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 LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years [400].

### 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[401].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C51 - Door Heater Control

---

[400] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[401] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

COINCIDENCE FACTOR[402]

The summer peak coincidence factor for this measure is assumed to be 0%[403].

---

**Algorithm**

---

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta$kWH  = kWbase * NUMdoors * ESF * BF

Where:

kWbase[404]  = 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[405]  = 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[406]  = 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

---

[402] Source partial list from DEER 2008

[403] 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.

[404] 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.

[405] 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.

[406] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**MEASURE CODE: CI-RFG-DHCT-V01-060112**

## 6.6.4 Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers

### DESCRIPTION

This measure is applicable to the replacement of an existing standard-efficiency shaded-pole evaporator fan motor in refrigerated display cases or fan coil in walk-ins.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

This measure applies to the replacement of an existing standard-efficiency shaded-pole evaporator fan motor in refrigerated display cases or fan coil in walk-ins. The replacement unit must be an electronically commutated motor (ECM). This measure cannot be used in conjunction with the evaporator fan controller measure

### DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a shaded pole motor

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years[407]

### DEEMED MEASURE COST

The measure cost is assumed to be $50 for a walk in cooler and walk in freezer. [408]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C22 - Commercial Refrigeration

### COINCIDENCE FACTOR

The measure has deemed peak kW savings therefore a coincidence factor does not apply.

---

[407] DEER
[408] Act on Energy Commercial Technical Reference Manual No. 2010-4

---

**Algorithm**

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**CALCULATION OF SAVINGS** [409]

Savings values are obtained from the SCE workpaper for efficient evaporator fan motors, which covers all 16 California climate zones. SCE savings values were determined using a set of assumed conditions for restaurants and grocery stores. We have used only PG&E climate zones in calculating our averages and have taken out the drier, warmer climates of southern California. SCE's savings approach calculates refrigeration demand, by taking into consideration temperature, compressor efficiency, and various loads involved for both walk-in and reach-in refrigerators. Details on cooling load calculations, including refrigeration conditions, can be found in the SCE workpaper. The baseline for this measure assumes that the refrigeration unit has a shaded-pole motor. The following tables are values calculated within the SCE workpaper.

Table 156 SCE Restaurant Savings Walk-In

| SCE Workpaper Values | Restaurant | | | |
| | Cooler | | Freezer | |
| Northern California Climate Zones | kWh Savings Per Motor | Peak kW Savings Per Motor | kWh Savings Per Motor | Peak kW Savings Per Motor |
|---|---|---|---|---|
| 1 | 318 | 0.0286 | 507 | 0.03 |
| 2 | 253 | 0.033 | 263 | 0.037 |
| 3 | 364 | 0.0315 | 649 | 0.034 |
| 4 | 365 | 0.0313 | 652 | 0.034 |
| 5 | 350 | 0.0305 | 605 | 0.033 |
| 11 | 410 | 0.0351 | 780 | 0.04 |
| 12 | 399 | 0.034 | 748 | 0.039 |
| 13 | 407 | 0.0342 | 771 | 0.039 |
| 16 | 354 | 0.0315 | 620 | 0.034 |
| Average | 358 | 0.0322 | 622 | 0.036 |

---

[409] "Efficient Evaporator Fan Motors (Shaded Pole to ECM)," Workpaper WPSCNRRN0011. Southern California Edison Company. 2007.

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Table 157: SCE Grocery Savings Walk-In

| SCE Workpaper Values | Grocery | | | |
|---|---|---|---|---|
| | Cooler | | Freezer | |
| Northern California Climate Zones | kWh Savings Per Motor | Peak kW Savings Per Motor | kWh Savings Per Motor | Peak kW Savings Per Motor |
| 1 | 318 | 0.0284 | 438 | 0.03 |
| 2 | 252 | 0.0534 | 263 | 0.064 |
| 3 | 364 | 0.0486 | 552 | 0.056 |
| 4 | 365 | 0.048 | 553 | 0.055 |
| 5 | 349 | 0.0452 | 516 | 0.051 |
| 11 | 410 | 0.0601 | 656 | 0.074 |
| 12 | 398 | 0.0566 | 631 | 0.069 |
| 13 | 406 | 0.0574 | 649 | 0.07 |
| 16 | 354 | 0.0486 | 528 | 0.056 |
| Average | 357 | 0.0496 | 532 | 0.058 |

Table 158: SCE Grocery Savings Reach-In

| SCE Workpaper Values | Grocery | | | |
|---|---|---|---|---|
| | Cooler | | Freezer | |
| Northern California Climate Zones | kWh Savings Per Motor | Peak kW Savings Per Motor | kWh Savings Per Motor | Peak kW Savings Per Motor |
| 1 | 306 | 0.031 | 362 | 0.031 |
| 2 | 269 | 0.033 | 273 | 0.035 |
| 3 | 331 | 0.032 | 421 | 0.034 |
| 4 | 332 | 0.032 | 422 | 0.034 |
| 5 | 323 | 0.032 | 402 | 0.033 |
| 11 | 357 | 0.034 | 476 | 0.037 |
| 12 | 350 | 0.034 | 462 | 0.036 |
| 13 | 355 | 0.034 | 472 | 0.037 |
| 16 | 325 | 0.032 | 409 | 0.034 |
| Average | 328 | 0.033 | 411 | 0.035 |

Savings values in the following table are an average of walk-in cooler (80 percent) and freezer (20 percent) applications. The workpapers for the 2006-2008 program years include this distribution of coolers and freezers in their refrigeration measure savings analyses.

**ELECTRIC ENERGY SAVINGS**

The following table provides the kWh savings.

| Building type | kWh Savings/ft |
|---|---|
| Restaurant | 411 |
| Grocery | 392 |
| Average | 401 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

The following table provides the kW savings

| Building Type | Peak kW Savings/motor |
|---|---|
| Restaurant | 0.033 |
| Grocery | 0.051 |
| Average | 0.042 |

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-RFG-ECMF-V01-060112**

## 6.6.5 ENERGY STAR Refrigerated Beverage Vending Machine

### DESCRIPTION

ENERGY STAR qualified new and rebuilt vending machines incorporate more efficient compressors, fan motors, and lighting systems as well as low power mode option that allows the machine to be placed in low-energy lighting and/or low-energy refrigeration states during times of inactivity.

This measure was developed to be applicable to the following program types: TOS, NC .
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The refrigerated vending machine can be new or rebuilt but must meet the ENERGY STAR specifications which include low power mode.

### DEFINITION OF BASELINE EQUIPMENT

The baseline vending machine is a standard unit

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of this measure is 14 years[410]

### DEEMED MEASURE COST

The incremental cost of this measure is $500[411]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C22 - Commercial Refrigeration

### COINCIDENCE FACTOR

It is assumed that controls are only effective during off-peak hours and so have no peak-kW savings.

---

**Algorithm**

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### CALCULATION OF SAVINGS

Beverage machine savings are taken from the ENERGY STAR savings calculator and summarized in the following table. ENERGY STAR provides savings numbers for machines with and without control software. The average

---

[410] ENERGY STAR
[411] ENERGY STAR

savings are calculated here.

**ELECTRIC ENERGY SAVINGS**

ENERGY STAR Vending Machine Savings[412]

| Vending Machine Capacity (cans) | kWh Savings Per Machine w/o software | kWh Savings Per Machine w/ software |
|---|---|---|
| <500 | 1,099 | 1,659 |
| 500 | 1,754 | 2,231 |
| 699 | 1,242 | 1,751 |
| 799 | 1,741 | 2,283 |
| 800+ | 713 | 1,288 |
| Average | 1,310 | 1,842 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-RFG-ESVE-V01-060112**

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[412] Savings from Vending Machine Calculator:
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=VMC

## 6.6.6    Evaporator Fan Control

### DESCRIPTION

This measure is for the installation of controls in existing medium temperature walk-in coolers. The controller reduces airflow of the evaporator fans when there is no refrigerant flow.

This measure was developed to be applicable to the following program types:  RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The measure must control a minimum of 1/20 HP where fans operate continuously at full speed. The measure also must reduce fan motor power by at least 75% during the off cycle. This measure is not applicable if any of the following conditions apply:

- The compressor runs all the time with high duty cycle
- The evaporator fan does not run at full speed all the time
- The evaporator fan motor runs on poly-phase power
- Evaporator does not use off-cycle or time-off defrost.

### DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline measure is assumed to be a cooler with continuously running evaporator fan.  An ECM can also be updated with controls.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 16 years[413]

### DEEMED MEASURE COST

The measure cost is assumed to be $291[414]

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C46 - Evaporator Fan Control

### COINCIDENCE FACTOR

The measure has deemed kW savings therefore a coincidence factor does not apply.

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[413] Source: DEER
[414] Source: DEER

---

**Algorithm**

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CALCULATION OF SAVINGS

Savings for this measure were obtained from the DEER database and are summarized in the following table. The baseline is assumed to be evaporator fans that run continuously with either a permanent split capacitor or shaded-pole motors. In the energy-efficient case the fan is still assumed to operate even with the evaporator inactive[415].

ELECTRIC ENERGY SAVINGS

DEER provides savings numbers for building vintages and grocery only. The numbers above are averages of these vintages. We are assuming that this measure will be applicable for all building types

The following table provides the kWh savings

| Northern California Climate Zones | kWh Savings Per Motor |
|---|---|
| 1 | 480 |
| 2 | 476 |
| 3 | 479 |
| 4 | 475 |
| 5 | 477 |
| 11 | 476 |
| 12 | 476 |
| 13 | 476 |
| 16 | 483 |
| Average | 478 |

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The following table provides the kW savings

| Northern California Climate Zones | Peak kW Savings Per Motor |
|---|---|
| 1 | 0.057 |
| 2 | 0.064 |
| 3 | 0.062 |
| 4 | 0.061 |
| 5 | 0.056 |
| 11 | 0.058 |
| 12 | 0.065 |
| 13 | 0.061 |
| 16 | 0.061 |

---

415 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report

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| | |
|---|---|
| Average | 0.06 |

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-RFG-EVPF-V01-060112**

## 6.6.7   Strip Curtain for Walk-in Coolers and Freezers

**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 the walk-in door is open 72 minutes per day every day, and the strip curtain covers the entire door frame.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

**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 LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 6 years[416].

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $10.22 per square foot of door opening (includes material and labor) [417].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape C22 - Commercial Refrigeration

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is 100%[418].

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[416] 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.
[417] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008
[418] The summer coincident peak demand reduction is assumed as the total annual savings divided by the total

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**[419]

  ΔkWh = 2,974 per freezer with curtains installed

     = 422 per cooler with curtains installed

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

  ΔkW = ΔkWh / 8760 * CF

    = 0.35 for freezers

    = 0.05 for coolers

Where:

  8766 = hours per year

  CF  = Summer Peak Coincidence Factor for the measure

    = 1.0

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-RFG-CRTN-V01-060112**

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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.

[419] 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.

---

## 6.7 Miscellaneous End Use

### 6.7.1 VSD Air Compressor

#### DESCRIPTION

This measure relates to the installation of an air compressor with a variable frequency drive, load/no load controls or variable displacement control. The baseline compressors defined choke off the inlet air to modulate the compressor output, which is not efficient. Efficient compressors use a variable speed drive on the motor to match output to the load. Savings are calculated using representative baseline and efficient demand numbers for compressor capacities according to the facility's load shape, and the number of hours the compressor runs at that capacity. Demand curves are as per DOE data for a Variable Speed compressor versus a Modulating compressor. This measure applies only to an individual compressor ≤ 40 hp

This measure was developed to be applicable to the following program types: TOS.
If applied to other program types, the measure savings should be verified.

#### DEFINITION OF EFFICIENT EQUIPMENT

The high efficiency equipment is a compressor ≤ 40 hp with variable speed control.

#### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a modulating compressor with blow down ≤ 40 hp

#### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

10 years.

#### DEEMED MEASURE COST

IncrementalCost ($) = $(127 \times hp_{compressor}) + 1446$

Where:

$127$ and $1446$[420] = compressor motor nominal hp to incremental cost conversion factor and offset

$hp_{compressor}$ = compressor motor nominal

#### DEEMED O&M COST ADJUSTMENTS

N/A

---

[420] Conversion factor and offset based on a linear regression analysis of the relationship between air compressor motor nominal horsepower and incremental cost. Several Vermont vendors were surveyed to determine the cost of equipment. See "Compressed Air Analysis.xls" and "Compiled Data ReQuest Results.xls" for incremental cost details.

Loadshape C35 - Industrial Process

**COINCIDENCE FACTOR**

The coincidence factor equals 0.95

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = 0.9 \times hp_{compressor} \times HOURS \times (CF_b - CF_e)$$

Where:

$\Delta kWh$ = gross customer annual kWh savings for the measure

$hp_{compressor}$ = compressor motor nominal hp

$0.9$[421] = compressor motor nominal hp to full load kW conversion factor

HOURS = compressor total hours of operation below depending on shift

| Shift | Hours |
|---|---|
| Single shift (8/5) | 1976 hours<br>7 AM – 3 PM, weekdays, minus some holidays and scheduled down time |
| 2-shift (16/5) | 3952 hours<br>7AM – 11 PM, weekdays, minus some holidays and scheduled down time |
| 3-shift (24/5) | 5928 hours<br>24 hours per day, weekdays, minus some holidays and scheduled down time |
| 4-shift (24/7) | 8320 hours<br>24 hours per day, 7 days a week minus some holidays and scheduled down time |

$CF_b$ = baseline compressor factor[422]

---

[421] Conversion factor based on a linear regression analysis of the relationship between air compressor motor nominal horsepower and full load kW from power measurements of 72 compressors at 50 facilities on Long Island. See "BHP Weighted Compressed Air Load Profiles v2.xls".

[422] Compressor factors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp. "See "BHP Weighted Compressed Air Load Profiles.xls" for source data and calculations (The "variable speed drive" compressor factor

=0.890

CF$_e$          = efficient compressor [423]

=0.705

---

**EXAMPLE**

For example a VFD compressor with 10 HP operating in a 1 shift facility would save

ΔkWh          = 0.9 x 10 x 1976 x (0.890 – 0.705)

= 3290 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW          = ΔkWh / HOURS * CF

---

**EXAMPLE**

For example a VFD compressor with 10 HP operating in a 1 shift facility would save

ΔkW          = 3290/1976*.95

= 1.58 kW

---

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-MSC-VSDA-V01-060112**

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has been adjusted up from the 0.675 presented in the analysis to 0.705 to account for the additional power draw of the VSD).

[423] Ibid.

# 7 Residential Measures

## 7.1 Appliances End Use

### 7.1.1 ENERGY STAR Air Purifier/Cleaner

**DESCRIPTION**

An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the current federal standard.

This measure was developed to be applicable to the following program types: TOS, NC.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

The efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR as provided below.

- Must produce a minimum 50 Clean Air Delivery Rate (CADR) for Dust[424] to be considered under this specification.
- Minimum Performance Requirement: = 2.0 CADR/Watt (Dust)
- Standby Power Requirement: = 2.0 Watts Qualifying models that perform secondary consumer functions (e.g. clock, remote control) must meet the standby power requirement.
- UL Safety Requirement: Models that emit ozone as a byproduct of air cleaning must meet UL Standard 867 (ozone production must not exceed 50ppb)

**DEFINITION OF BASELINE EQUIPMENT**

The baseline equipment is assumed to be a conventional unit[425].

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 9 years[426].

**DEEMED MEASURE COST**

The incremental cost for this measure is $70.[427]

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[424] Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard
[425] As defined as the average of non-ENERGY STAR products found in EPA research, 2008, ENERGY STAR Qualified Room Air Cleaner Calculator,
 http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.
[426] ENERGY STAR Qualified Room Air Cleaner Calculator,
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.
[427] Ibid

**DEEMED O&M COST ADJUSTMENTS**

There are no operation and maintenance cost adjustments for this measure.[428]

**LOADSHAPE**

Loadshape C53 - Flat

**COINCIDENCE FACTOR**

The summer peak coincidence factor for this measure is assumed to be 100 % (the unit is assumed to be always on).

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$$

Where:

$kWh_{BASE}$ = Baseline kWh consumption per year[429]

= see table below

$kWh_{ESTAR}$ = ENERGY STAR kWh consumption per year[430]

= see table below

| Clean Air Delivery Rate | Baseline Unit Energy Consumption (kWh/year) | ENERGY STAR Unit Energy Consumption (kWh/year) | ΔkWH |
|---|---|---|---|
| CADR 51-100 | 596 | 329 | 268 |
| CADR 101-150 | 1,072 | 548 | 525 |
| CADR 151-200 | 1,480 | 767 | 714 |
| CADR 201-250 | 1,887 | 986 | 902 |
| CADR Over 250 | 1,641 | 1205 | 437 |

---

[428] Some types of room air cleaners require filter replacement or periodic cleaning, but this is likely to be true for both efficient and baseline units and so no difference in cost is assumed.
[429] ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b
[430] Ibid.

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

ΔkWh           = Gross customer annual kWh savings for the measure

Hours          = Average hours of use per year

                   = 8766 hours[431]

CF              = Summer Peak Coincidence Factor for measure

                   = 1.0

| Clean Air Delivery Rate | ΔkW |
|---|---|
| CADR 51-100 | 0.031 |
| CADR 101-150 | 0.060 |
| CADR 151-200 | 0.081 |
| CADR 201-250 | 0.103 |
| CADR Over 250 | 0.050 |

**NATURAL GAS SAVINGS**

**N/A**

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

**N/A**

**MEASURE CODE: RS-APL-ESAP-V01-060112**

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[431] Consistent with ENERGY STAR Qualified Room Air Cleaner Calculator.

## 7.1.2   ENERGY STAR and CEE Tier 2 and 3 Clothes Washers

### DESCRIPTION

This measure relates to the installation of a clothes washer meeting the Energy Star, or CEE Tier 2 or Tier 3 minimum qualifications. Note if the DHW and dryer fuels of the installations are unknown (for example through a retail program) savings should be based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site specific savings where DHW and dryer fuels are known.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

Clothes washer must meet the ENERGY STAR or CEE Tier 2 or 3 minimum qualifications, as required by the program.

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a clothes washer meeting the minimum federal baseline.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 14 years[432].

### DEEMED MEASURE COST

The incremental cost for an Energy Star unit is assumed to be $210, for a CEE Tier 2 unit is $360 and for a CEE Tier 3 unit it is $458[433].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R01 - Residential Clothes Washer

---

[432] Based on DOE Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html
[433] Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and attempts to find the costs associated only with the efficiency improvements.

COINCIDENCE FACTOR

The coincidence factor for this measure is 3.8%[434].

---

**Algorithm**

---

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

1. Calculate clothes washer savings based on Modified Energy Factor (MEF).

   The Modified Energy Factor (MEF) includes unit operation, water heating and drying energy use: *"MEF is the quotient of the capacity of the clothes container, C, divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, M, the hot water energy consumption, E, and the energy required for removal of the remaining moisture in the wash load, D"* [435].

   The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

   MEFsavings[436]     = Capacity * (1/MEFbase - 1/MEFeff) * Ncycles

Where

   Capacity     = Clothes Washer capacity (cubic feet)

                = Actual. If capacity is unknown assume 3.5 cubic feet [437]

   MEFbase      = Modified Energy Factor of baseline unit

                = 1.64[438]

   MEFeff       = Modified Energy Factor of efficient unit

                = Actual. If unknown assume average values provided below.

   Ncycles      = Number of Cycles per year

                = 295[439]

---

[434] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

435 Definition provided on the Energy star website.

436 Tsavings represents total kWh only when water heating and drying are 100% electric.

437 Based on the average clothes washer volume of all post-1/1/2007 units from the California Energy Commission (CEC) database of Clothes Washer products.

If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[438] Average MEF of non-ENERGY STAR units from the California Energy Commission (CEC) database of Clothes Washer products.

[439] Weighted average of 295 clothes washer cycles per year (based on 2009 Residential Energy Consumption

MEFsavings is provided below based on deemed values[440]:

| Efficiency Level | MEF | MEFSavings (kWh) |
|---|---|---|
| Federal Standard | 1.64 | 0.0 |
| Energy Star | 2.07 | 130 |
| CEE Tier 2 | 2.28 | 177 |
| CEE Tier 3 | 2.71 | 248 |

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

$\Delta kWh$ = [(Capacity * 1/MEFbase * Ncycles) * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer)]

Where:

%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)

%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)

%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)

| | Percentage of Total Energy Consumption[441] | | |
|---|---|---|---|
| | %CW | %DHW | %Dryer |
| Baseline | 7% | 33% | 59% |
| Non-CEE Energy Star Units | 6% | 31% | 62% |
| CEE 2 | 8% | 24% | 68% |
| CEE 3 | 10% | 16% | 74% |

%Electric_DHW = Percentage of DHW savings assumed to be electric

---

Survey (RECS) national sample survey of housing appliances section, state of IL: http://www.eia.gov/consumption/residential/data/2009/
If utilities have specific evaluation results providing a more appropriate assumption for single-family or multi-family homes, in a particular market, or geographical area then that should be used.

[440] MEF values are the average of the from the California Energy Commission (CEC) database of Clothes Washer products .. See "CW Analysis.xls" for the calculation.

[441] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a sales weighted average of top loading and front loading units based on data from Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html. See "CW Analysis.xls" for the calculation.

| DHW fuel | %Electric_DHW |
|---|---|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 16%[442] |

%Electric_Dryer   = Percentage of dryer savings assumed to be electric

| Dryer fuel | %Electric_DHW |
|---|---|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 27%[443] |

In summation, the complete algorithm is as follows:

ΔkWH   = [(Capacity  *  1/MEFbase  *  Ncycles)  *  (%CWbase + (%DHWbase  *  %Electric_DHW) + (%Dryerbase * %Electric_Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer)]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

| | ΔkWH | | | |
|---|---|---|---|---|
| | Electric DHW Electric Dryer | Gas DHW Electric Dryer | Electric DHW Gas Dryer | Gas DHW Gas Dryer |
| Non-CEE Energy Star Units | 129.6 | 75.7 | 69.8 | 15.9 |
| CEE 2 | 177.2 | 76.4 | 112.8 | 12.0 |
| CEE 3 | 248.0 | 99.0 | 157.3 | 8.3 |

If the DHW and dryer fuel is unknown the prescriptive kWH savings based on defaults provided above should be:

| | ΔkWH |
|---|---|
| Non-CEE Energy Star Units | 40.69 |
| CEE 2 | 45.52 |
| CEE 3 | 56.63 |

---

[442] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[443] Default assumption for unknown is based on percentage of homes with electric dryer from EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

= 295 hours[444]

CF = Summer Peak Coincidence Factor for measure.

= 0.038[445]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

| | ΔkW | | | |
|---|---|---|---|---|
| | **Electric DHW Electric Dryer** | **Gas DHW Electric Dryer** | **Electric DHW Gas Dryer** | **Gas DHW Gas Dryer** |
| Non-CEE Energy Star Units | 0.017 | 0.010 | 0.009 | 0.002 |
| CEE 2 | 0.023 | 0.010 | 0.015 | 0.002 |
| CEE 3 | 0.032 | 0.013 | 0.020 | 0.001 |

If the DHW and dryer fuel is unknown the prescriptive kW savings should be:

| | **ΔkW** |
|---|---|
| Non-CEE Energy Star Units | 0.005 |
| CEE 2 | 0.006 |
| CEE 3 | 0.007 |

**NATURAL GAS SAVINGS**

Break out savings calculated in Step 1 of electric energy savings (MEF savings) and extract Natural Gas DHW and Natural Gas dryer savings from total savings:

ΔTherm = [(Capacity * 1/MEFbase * Ncycles) * ((%DHWbase * %Natural Gas_DHW * R_eff) + (%Dryerbase

---

[444] Based on a weighted average of 295 clothes washer cycles per year assuming an average load runs for one hour (2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section: http://www.eia.gov/consumption/residential/data/2009/)

[445] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

* %Gas _Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * ((%DHWeff * %Natural Gas_DHW * R_eff) + (%Dryereff * %Gas_Dryer)] * Therm_convert

Where:

Therm_convert = Convertion factor from kWh to Therm

= 0.03413

R_eff = Recovery efficiency factor

= 1.26[446]

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

| DHW fuel | %Natural Gas_DHW |
|----------|------------------|
| Electric | 0% |
| Natural Gas | 100% |
| Unknown | 84%[447] |

%Gas_Dryer = Percentage of dryer savings assumed to be Natural Gas

| Dryer fuel | %Gas_Dryer |
|------------|------------|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 44%[448] |

Other factors as defined above

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

| | ΔTherms | | | |
|---|---|---|---|---|
| | Electric DHW Electric Dryer | Gas DHW Electric Dryer | Electric DHW Gas Dryer | Gas DHW Gas Dryer |
| Non-CEE Energy Star Units | 0.00 | 2.32 | 2.04 | 4.36 |
| CEE 2 | 0.00 | 4.34 | 2.20 | 6.53 |
| CEE 3 | 0.00 | 6.41 | 3.10 | 9.50 |

---

[446] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf ). Therefore a factor of 0.98/0.78 (1.26) is applied.

[447] Default assumption for unknown fuel is based on percentage of homes with gas dryer from EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[448] Ibid.

If the DHW and dryer fuel is unknown the prescriptive Therm savings should be:

|  | ΔTherms |
| --- | --- |
| Non-CEE Energy Star Units | 2.84 |
| CEE 2 | 4.61 |
| CEE 3 | 6.74 |

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

$$\Delta Water\ (gallons) = (Capacity * (WFbase - WFeff)) * Ncycles$$

Where

WFbase = Water Factor of baseline clothes washer

= 7.59[449]

WFeff = Water Factor of efficient clothes washer

= Actual. If unknown assume average values provided below.

Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

| Efficiency Level | WF[450] | ΔWater (gallons per year) |
| --- | --- | --- |
| Federal Standard | 7.59 | 0.0 |
| Energy Star | 4.75 | 2,934 |
| CEE Tier 2 | 4.15 | 3,557 |
| CEE Tier 3 | 3.46 | 4,264 |

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESCL-V01-060112**

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[449] Average MEF of non-ENERGY STAR units.

[450] Water Factor is the number of gallons required for each cubic foot of laundry. WF values are the average of the CEC data set. See "CW Analysis.xls" for the calculation.

## 7.1.3   ENERGY STAR Dehumidifier

DESCRIPTION

A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR (Version 2.1 or 3.0)[451] is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure, the new dehumidifier must meet the ENERGY STAR standards as defined below:

Until 9/30/2012:

| 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 |

After 10/1/2012[452]:

| Capacity (pints/day) | ENERGY STAR Criteria (L/kWh) |
|---|---|
| <75 | ≥1.85 |
| 75 to ≤185 | ≥2.80 |

Qualifying units shall be equipped with an adjustable humidistat control or shall require a remote humidistat control to operate.

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:

---

[451] Energy Star Version 3.0 will become effective 10/1/12
[452] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dehumid/ES_Dehumidifiers_Final_V3.0_Eligibility_Criteria.pdf?d70c-99b0

| 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 LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 12 years[453].

DEEMED MEASURE COST

The assumed incremental capital cost for this measure is $45[454].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R12 - Residential - Dehumidifier

COINCIDENCE FACTOR

The coincidence factor is assumed to be 37% [455].

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (((\text{Avg Capacity} * 0.473) / 24) * \text{Hours}) * (1 / (\text{L/kWh\_Base}) - 1 / (\text{L/kWh\_Eff}))$$

Where:

---

[453] ENERGY STAR Dehumidifier Calculator
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls
[454] 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
[455] 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%

| | |
|---|---|
| Avg Capacity | = Average capacity of the unit (pints/day) |
| 0.473 | = Constant to convert Pints to Liters |
| 24 | = Constant to convert Liters/day to Liters/hour |
| Hours | = Run hours per year |
| | = 1620 [456] |
| L/kWh | = Liters of water per kWh consumed, as provided in tables above |

Annual kWh results for each capacity class are presented below:

Until 9/30/2012 (V 2.1):

| Capacity (pints/day) Range | Avg Capacity | Annual kWh | | |
|---|---|---|---|---|
| | | ENERGY STAR | Federal Standard | Savings |
| ≤25 | 22.4 | 596 | 650 | 54 |
| > 25 to ≤35 | 30 | 684 | 802 | 117 |
| > 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 |

After 10/1/2012 (V 3.0):

| Capacity (pints/day) Range | Avg Capacity[457] | Annual kWh | | |
|---|---|---|---|---|
| | | ENERGY STAR | Federal Standard[458] | Savings |
| <75 | 68 | 1174 | 1401 | 227 |
| 75 to ≤185 | 127 | 1448 | 2134 | 686 |

**Summer Coincident Peak Demand Savings**

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

---

[456] ENERGY STAR Dehumidifier Calculator
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls
[457] Average capacity of current Energy Star qualified products (2/8/2012) that will qualify under V 3.0
[458] Assuming 1.55 kWh/L for units of capacity <75, and 1.90 kWh/L for units of capacity 75 to ≤185

Where:

Hours = Annual operating hours[459]

= 1620 hours

CF = Summer Peak Coincidence Factor for measure

= 0.37 [460]

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

Until 9/30/2012 (V 2.1):

| Capacity Range | Annual Summer peak kW Savings |
|---|---|
| ≤25 | 0.012 |
| > 25 to ≤35 | 0.027 |
| > 35 to ≤45 | 0.048 |
| > 45 to ≤ 54 | 0.068 |
| > 54 to ≤ 75 | 0.042 |
| > 75 to ≤ 185 | 0.085 |

After 10/1/2012 (V 3.0):

| Capacity (pints/day) Range | Annual Summer peak kW Savings |
|---|---|
| <75 | 0.052 |
| 75 to ≤185 | 0.157 |

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESDH-V01-060112**

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[459] 1620 operating hours from ENERGY STAR Dehumidifier Calculator
[460] 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%

## 7.1.4    ENERGY STAR Dishwasher

DESCRIPTION

A dishwasher meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a dishwasher meeting the efficiency specifications of ENERGY STAR (for standard and compact dishwashers). The Energy Star standard is presented in the table below:

| Dishwasher Type | Maximum kWh/year | Maximum gallons/cycle |
|---|---|---|
| Standard | 295 | 4.25 |
| Compact | 222 | 3.5 |

DEFINITION OF BASELINE EQUIPMENT

The Baseline reflects the minimum federal efficiency standards for dishwashers effective January 1, 2010, as presented in the table below.

| Dishwasher Type | Maximum kWh/year | Maximum gallons/cycle |
|---|---|---|
| Standard | 355 | 6.5 |
| Compact | 260 | 4.5 |

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 13 years[461].

DEEMED MEASURE COST

The incremental cost for this measure is $50[462].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R02 - Residential Dish Washer

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[461] Koomey, Jonathan et al. (Lawrence Berkeley National Lab), Projected Regional Impacts of Appliance Efficiency Standards for the U.S. Residential Sector, February 1998.
[462] Estimate based on review of Energy Star stakeholder documents

COINCIDENCE FACTOR

The coincidence factor is assumed to be 2.6%[463].

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh^{464} = ((kWh_{Base} - kWh_{ESTAR}) * (\%kWh\_op + (\%kWh\_heat * \%Electric\_DHW )))$$

Where:

| | |
|---|---|
| $kWh_{BASE}$ | = Baseline kWh consumption per year |
| | = 355 kWh for standard |
| | = 260 kWh for Compact |
| $kWh_{ESTAR}$ | = ENERGY STAR kWh annual consumption |
| | = 295 kWh for standard |
| | = 222 kWh for compact |
| %kWh_op | = Percentage of dishwasher energy consumption used for unit operation |
| | = 1 - 56%[465] |
| | = 44% |
| %kWh_heat | = Percentage of dishwasher energy consumption used for water heating |
| | = 56%[466] |
| %Electric_DHW | = Percentage of DHW savings assumed to be electric |

| DHW fuel | %Electric_DHW |
|---|---|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 16%[467] |

---

[463] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
[464] The Federal Standard and ENERGY STAR annual consumption values include electric consumption for both the operation of the machine and for heating the water that is used by the machine.
[465] ENERGY STAR Dishwasher Calculator
(http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls)
[466] Ibid.
[467] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for

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An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta kWh = ((355 - 295) * (0.44 + (0.56*0.16)))$$

$$= 31.8 \text{ kWh}$$

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta kWh = ((260 - 222) * (0.44 + (0.56*0.16)))$$

$$= 20.1 \text{ kWh}$$

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

$$\Delta kWh = ((355 - 295) * (0.44 + (0.56*1.0)))$$

$$= 60.0 \text{ kWh}$$

An Energy Star compact dishwasher installed in place of a baseline unit with electric DHW:

$$\Delta kWh = ((260 - 222) * (0.44 + (0.56*1.0)))$$

$$= 38.0 \text{ kWh}$$

**Summer Coincident Peak Demand Savings**

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

Where:

Hours   = Annual operating hours[468]

= 252 hours

CF   = Summer Peak Coincidence Factor

= 2.6% [469]

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta kWh = 31.8/252 * 0.026$$

---

Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[468] Assuming one and a half hours per cycle and 168 cycles per year therefore 252 operating hours per year; 168 cycles per year is based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data; http://205.254.135.7/consumption/residential/data/2009/

[469] End use data from Ameren representing the average DW load during peak hours/peak load.

= 0.003 kW

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

$\Delta$kWh   = 20.1/252 * 0.026

          = 0.002 kWh

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

$\Delta$kWh   = 60.0/252 * 0.026

          = 0.006 kWh

An Energy Star compact dishwasher installed in place of a baseline unit with electric DHW:

$\Delta$kWh   = 38.0/252 * 0.026

          = 0.004 kWh

**NATURAL GAS SAVINGS**

$\Delta$ Therm = (kWh$_{Base}$ - kWh$_{ESTAR}$) * %kWh_heat * %Natural Gas_DHW * R_eff * 0.03413

Where

%kWh_heat       = % of dishwasher energy used for water heating

                = 56%

%Natural Gas_DHW      = Percentage of DHW savings assumed to be Natural Gas

| DHW fuel | %Natural Gas_DHW |
|---|---|
| Electric | 0% |
| Natural Gas | 100% |
| Unknown | 84%[470] |

R_eff          = Recovery efficiency factor

                = 1.26[471]

0.03413          = factor to convert from kWh to Therm

---

[470] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[471] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelin es.pdf). Therefore a factor of 0.98/0.78 (1.26) is applied.

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta \text{ Therm} = (355 - 295) * 0.56 * 0.84 * 1.26 * 0.03413$$

$$= 1.26 \text{ Therm}$$

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta \text{ Therm} = (260 - 222) * 0.56 * 0.84 * 1.26 * 0.03413$$

$$= 0.77 \text{ Therm}$$

An Energy Star standard dishwasher installed in place of a baseline unit with gas DHW:

$$\Delta \text{ Therm} = (355 - 295) * 0.56 * 1.0 * 1.26 * 0.03413$$

$$= 1.44 \text{ Therm}$$

An Energy Star compact dishwasher installed in place of a baseline unit with gas DHW:

$$\Delta \text{ Therm} = (260 - 222) * 0.56 * 1.0 * 1.26 * 0.03413$$

$$= 0.92 \text{ Therm}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

$$\Delta \text{Water} = \text{Water}_{Base} - \text{Water}_{EFF}$$

Where

$\text{Water}_{Base}$ = water consumption of conventional unit

= 1008 gallons[472] for standard unit

= 672 gallons[473] for compact

$\text{Water}_{EFF}$ = annual water consumption of efficient unit:

= 672 gallons[474] for standard unit

---

[472] Assuming 6 gallons/cycle based on ENERGY STAR Dishwasher Calculator
(http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls )
and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs
data; http://205.254.135.7/consumption/residential/data/2009/
[473] Assuming 4 gallons/cycle for baseline unit
[474] Assuming 4gallons/cycle based on ENERGY STAR Dishwasher Calculator

$$= 504 \text{ gallons}^{475} \text{ for compact}$$

Δ Water (Standard)     = 1008 – 672

$$= 336 \text{ gallons}$$

Δ Water (Compact)     = 672 – 504

$$= 168 \text{ gallons}$$

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESDI-V01-060112**

---

(http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls )
and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs
data; http://205.254.135.7/consumption/residential/data/2009/
[475] Assuming 3 gallons/cycle for efficient unit

## 7.1.5   ENERGY STAR Freezer

DESCRIPTION

A freezer meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard (NAECA). Energy usage specifications are defined in the table below (note, AV is the freezer Adjusted Volume and is calculated as 1.73*Total Volume):[476]

| Product Category | NAECA Maximum Energy Usage in kWh/year[477] | ENERGY STAR Maximum Energy Usage in kWh/year[478] | Volume (cubic feet) |
|---|---|---|---|
| Upright Freezers with Manual Defrost | 7.55*AV+258.3 | 6.795*AV+232.47 | 7.75 or greater |
| Upright Freezers with Automatic Defrost | 12.43*AV+326.1 | 11.187*AV+293.49 | 7.75 or greater |
| Chest Freezers and all other Freezers except Compact Freezers | 9.88*AV+143.7 | 8.892*AV+129.33 | 7.75 or greater |
| Compact Upright Freezers with Manual Defrost | 9.78*AV+250.8 | 7.824*AV+200.64 | < 7.75 and 36 inches or less in height |
| Compact Upright Freezers with Automatic Defrost | 11.40*AV+391 | 9.12*AV+312.8 | < 7.75 and 36 inches or less in height |
| Compact Chest Freezers | 10.45*AV+152 | 8.36*AV+121.6 | <7.75 and 36 inches or less in height |

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a freezer meeting the efficiency specifications of ENERGY STAR, as defined below and calculated above:

| Equipment | Volume | Criteria |
|---|---|---|
| Full Size Freezer | 7.75 cubic feet or greater | At least 10% more energy efficient than the minimum federal government standard (NAECA). |
| Compact Freezer | Less than 7.75 cubic feet and 36 inches or less in height | At least 20% more energy efficient than the minimum federal government standard (NAECA). |

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a model that meets the federal minimum standard for energy efficiency.

---

[476] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
[477] as of July 1, 2001
[478] as of April 28, 2008

The standard varies depending on the size and configuration of the freezer (chest freezer or upright freezer, automatic or manual defrost) and is defined in the table above.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 11 years[479].

### DEEMED MEASURE COST

The incremental cost for this measure is $35[480].

### DEEMED O&M COST ADJUSTMENTS

There are no operation and maintenance cost adjustments for this measure.

### LOADSHAPE

Loadshape R04 - Residential Freezer

### COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 95%[481].

---

### Algorithm

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### CALCULATION OF SAVINGS

### ELECTRIC ENERGY SAVINGS:

$$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$$

Where:

$kWh_{BASE}$ = Baseline kWh consumption per year as calculated in algorithm provided in table above.

$kWh_{ESTAR}$ = ENERGY STAR kWh consumption per year as calculated in algorithm provided in table above.

---

[479] Energy Star Freezer Calculator;
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Freezer_Sav_Calc.xls?570a-f000
[480] Based on review of data from the Northeast Regional ENERGY STAR Consumer Products Initiative; "2009 ENERGY STAR Appliances Practices Report", submitted by Lockheed Martin, December 2009.
[481] Based on eShapes Residential Freezer load data as provided by Ameren.

---

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

$$\Delta kWh = (7.55*(7.75* 1.73)+258.3) - (6.795*(7.75* 1.73)+232.47)$$

$$= 359.5 - 323.6$$

$$= 35.9 \text{ kWh}$$

If volume is unknown, use the following default values:

| Product Category | Volume Used[482] | kWh$_{BASE}$ | kWh$_{ESTAR}$ | kWh Savings |
|---|---|---|---|---|
| Upright Freezers with Manual Defrost | 27.9 | 469.1 | 422.2 | 46.9 |
| Upright Freezers with Automatic Defrost | 27.9 | 673.2 | 605.9 | 67.3 |
| Chest Freezers and all other Freezers except Compact Freezers | 27.9 | 419.6 | 377.6 | 42.0 |
| Compact Upright Freezers with Manual Defrost | 10.4 | 352.3 | 281.9 | 70.5 |
| Compact Upright Freezers with Automatic Defrost | 10.4 | 509.3 | 407.5 | 101.9 |
| Compact Chest Freezers | 10.4 | 260.5 | 208.4 | 52.1 |

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = \Delta kWh/ \text{Hours} * CF$$

Where:

$\Delta kWh$ = Gross customer annual kWh savings for the measure

Hours = Full Load hours per year

= 5890[483]

CF = Summer Peak Coincident Factor

---

[482] Volume is based on ENERGY STAR Calculator assumption of 16.14 ft$^3$ average volume, converted to Adjusted volume by multiplying by 1.73.

[483] Calculated from eShapes Residential Freezer load data as provided by Ameren by dividing total annual load by the maximum kW in any one hour.

$$= 0.95 \ ^{484}.$$

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

$$\Delta kW \quad = 35.9/5890 * 0.95$$

$$= 0.0058 \ kW$$

If volume is unknown, use the following default values:

| Product Category | kW Savings |
|---|---|
| Upright Freezers with Manual Defrost | 0.0076 |
| Upright Freezers with Automatic Defrost | 0.0109 |
| Chest Freezers and all other Freezers except Compact Freezers | 0.0068 |
| Compact Upright Freezers with Manual Defrost | 0.0114 |
| Compact Upright Freezers with Automatic Defrost | 0.0164 |
| Compact Chest Freezers | 0.0084 |

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESFR-V01-060112**

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[484] Based on eShapes Residential Freezer load data as provided by Ameren.

## 7.1.6    ENERGY STAR and CEE Tier 2 Refrigerator

### DESCRIPTION

This measure relates to the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications. Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 * Freezer Volume):[485]

| Product Category | NAECA as of July 1, 2001 Maximum Energy Usage in kWh/year | Current ENERGY STAR level Maximum Energy Usage in kWh/year |
|---|---|---|
| 1.  Refrigerators and Refrigerator-freezers with manual defrost | 8.82*AV+248.4 | 7.056*AV+198.72 |
| 2.  Refrigerator-Freezer--partial automatic defrost | 8.82*AV+248.4 | 7.056*AV+198.72 |
| 3.  Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 9.80*AV+276 | 7.84*AV+220.8 |
| 4.  Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 4.91*AV+507.5 | 3.928*AV+406 |
| 5.  Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 4.60*AV+459 | 3.68*AV+367.2 |
| 6.  Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 10.20*AV+356 | 8.16*AV+284.8 |
| 7.  Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 10.10*AV+406 | 8.08*AV+324.8 |

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is defined as a refrigerator meeting the efficiency specifications of ENERGY STAR or CEE Tier 2 (defined as requiring >= 20% or >= 25% less energy consumption than an equivalent unit meeting federal standard requirements respectively). The ENERGY STAR  standard varies according to the size and configuration of the unit, as shown in table above.

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency.  The current federal minimum standard varies according to the size and configuration of the unit, as shown in table above. Note also that this federal standard will be increased for units manufactured after January 1, 2014.

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[485] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The measure life is assumed to be 12 years.[486]

**DEEMED MEASURE COST**

The incremental cost for this measure is assumed to be $30[487] for an ENERGY STAR unit and $140[488] for a CEE Tier 2 unit.

**DEEMED O&M COST ADJUSTMENTS**

There are no operation and maintenance cost adjustments for this measure.

**LOADSHAPE**

Loadshape R05 - Residential Refrigerator

**COINCIDENCE FACTOR**

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

---

## Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS:**

$$\Delta kWh = UEC_{BASE} - UEC_{EE}$$

Where:

UEC$_{BASE}$ = Annual Unit Energy Consumption of baseline unit as calculated in algorithm provided in table above.

UEC$_{EE}$ = Annual Unit Energy Consumption of ENERGY STAR unit as calculated in algorithm provided in table above.

For CEE Tier 2, unit consumption is calculated as 25% lower than baseline.

---

[486] From ENERGY STAR calculator:
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls
[487] Ibid.
[488] 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

If volume is unknown, use the following defaults:

| Product Category | Volume Used[489] | $UEC_{base}$ | ENERGY STAR $UEC_{EE}$ | CEE T2 $UEC_{EE}$ | ENERGY STAR kWh Savings | CEE T2 kWh Savings |
|---|---|---|---|---|---|---|
| 1. Refrigerators and Refrigerator-freezers with manual defrost | 25.8 | 475.7 | 380.5 | 356.8 | 95.1 | 118.9 |
| 2. Refrigerator-Freezer--partial automatic defrost | 25.8 | 475.7 | 380.5 | 356.8 | 95.1 | 118.9 |
| 3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 25.8 | 528.5 | 422.8 | 396.4 | 105.7 | 132.1 |
| 4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 25.8 | 634.0 | 507.2 | 475.5 | 126.8 | 158.5 |
| 5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 25.8 | 577.5 | 462.0 | 433.2 | 115.5 | 144.4 |
| 6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 25.8 | 618.8 | 495.1 | 464.1 | 123.8 | 154.7 |
| 7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 25.8 | 666.3 | 533.0 | 499.7 | 133.3 | 166.6 |

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh/8766) * TAF * LSAF$$

Where:

TAF = Temperature Adjustment Factor

= 1.25[490]

---

[489] Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft$^3$ fresh volume and 6.76 ft$^3$ freezer volume.

[490] Average temperature adjustment factor (to account for temperature conditions during peak period as compared to year as a whole) based on Blasnik, Michael, "Measurement and Verification of Residential

LSAF             = Load Shape Adjustment Factor

                       = 1.057 [491]

If volume is unknown, use the following defaults:

| Product Category | ENERGY STAR kW Savings | CEE T2 kW Savings |
|---|---|---|
| 1.  Refrigerators and Refrigerator-freezers with manual defrost | 0.0143 | 0.0179 |
| 2.  Refrigerator-Freezer--partial automatic defrost | 0.0143 | 0.0179 |
| 3.  Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 0.0159 | 0.0199 |
| 4.  Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 0.0191 | 0.0239 |
| 5.  Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 0.0174 | 0.0218 |
| 6.  Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 0.0187 | 0.0233 |
| 7.  Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 0.0201 | 0.0251 |

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

---

Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47).  It assumes 90 °F average outside temperature during peak period, 71°F average temperature in kitchens and 65°F average temperature in basement, and uses assumption that 66% of homes in Illinois having central cooling (CAC saturation: "Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls )

[491] Daily load shape adjustment factor (average load in peak period /average daily load) also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48, using the average Existing Units Summer Profile for hours 13 through 17)

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESRE-V01-060112**

## 7.1.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner

**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[492]:

| Product Class (Btu/H) | Federal Standard EER, with louvered sides | Federal Standard EER, without louvered sides | ENERGY STAR EER, with louvered sides | ENERGY STAR EER, without louvered sides | CEE TIER 1 EER |
|---|---|---|---|---|---|
| < 8,000 | 9.7 | 9 | 10.7 | 9.9 | 11.2 |
| 8,000 to 13,999 | 9.8 | 8.5 | 10.8 | 9.4 | 11.3 |
| 14,000 to 19,999 | 9.7 | 8.5 | 10.7 | 9.4 | 11.2 |
| >= 20,000 | 8.5 | 8.5 | 9.4 | 9.4 | 9.8 |

| Casement | Federal Standard (EER) | ENERGY STAR (EER) |
|---|---|---|
| Casement-only | 8.7 | 9.6 |
| Casement-slider | 9.5 | 10.5 |

| Reverse Cycle - Product Class (Btu/H) | Federal Standard EER, with louvered sides | Federal Standard EER, without louvered sides | ENERGY STAR EER, with louvered sides | ENERGY STAR EER, without louvered sides |
|---|---|---|---|---|
| < 14,000 | N/A | 8.5 | N/A | 9.4 |
| >= 14,000 | N/A | 8 | N/A | 8.8 |
| < 20,000 | 9 | N/A | 9.9 | N/A |
| >= 20,000 | 8.5 | N/A | 9.4 | N/A |

This measure was developed to be applicable to the following program types: TOS, NC.
If applied to other program types, the measure savings should be verified.

---

[492] http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac and http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf
Side louvers that extend from a room air conditioner model in order to position the unit in a window. A model without louvered sides is placed in a built-in wall sleeve and are commonly referred to as "through-the-wall" or "built-in" models.
Casement-only refers to a room air conditioner designed for mounting in a casement window of a specific size.
Casement-slider refers to a room air conditioner with an encased assembly designed for mounting in a sliding or casement window of a specific size.
Reverse cycle refers to the heating function found in certain room air conditioner models.
http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the new room air conditioning unit must meet the ENERGY STAR 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 LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years[493].

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[494].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.3[495].

---

**Algorithm**

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$$

Where:

---

[493] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf
[494] Based on field study conducted by Efficiency Vermont
[495] 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)

---

$FLH_{RoomAC}$        = Full Load Hours of room air conditioning unit

= dependent on location[496]:

| Climate Zone (City based upon) | $FLH_{RoomAC}$ |
|---|---|
| 1 (Rockford) | 220 |
| 2 (Chicago) | 210 |
| 3 (Springfield) | 319 |
| 4 (Belleville) | 428 |
| 5 (Marion) | 374 |
| Weighted Average[497] | 248 |

Btu/H        = Size of rebated unit

= Actual. If unknown assume 8500 BTU/hour[498]

EERbase        = Efficiency of baseline unit

= As provided in tables above

EERee        = Efficiency of ENERGY STAR or CEE Tier 1 unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

---

For example for an 8,500 BTU/H capacity unit, with louvered sides, in an unknown location:

$\Delta kWH_{ENERGY\ STAR}$   = (248 * 8500 * (1/9.8 – 1/10.8)) / 1000

= 19.9kWh

$\Delta kWH_{CEE\ TIER\ 1}$   = (248 * 8500 * (1/9.8 – 1/11.3)) / 1000

= 28.6 kWh

---

[496] Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided 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) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[497] Weighted based on number of residential occupied housing units in each zone.

[498] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

CF $\qquad$ = Summer Peak Coincidence Factor for measure

$\qquad$ = 0.3[499]

Other variable as defined above

---

For example for an 8,500 BTU/H capacity unit, with louvered sides, for an unknown location:

$\Delta kW_{ENERGY\ STAR}$ $\qquad$ = (8500 * (1/9.8 – 1/10.8)) / 1000 * 0.3

$\qquad$ = 0.024 kW

$\Delta kW_{CEE\ TIER\ 1}$ $\qquad$ = (8500 * (1/9.8 – 1/11.3)) / 1000 * 0.3

$\qquad$ = 0.035 kW

---

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-ESRA-V01-060112**

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[499] 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)

## 7.1.8    Refrigerator and Freezer Recycling

### DESCRIPTION

This measure describes savings from the retirement and recycling of inefficient but operational refrigerators and freezers. Savings are provided based on a metering study that provides a regression equation that uses key inputs describing the retired unit. The savings are equivalent to the Unit Energy Consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A part use factor is applied to account for those secondary units that are not in use throughout the entire year.  The reader should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary.

The Net to Gross factor applied to these units should incorporate adjustments that account for:

- Those participants who would have removed the unit from the grid anyway (e.g. customers replacing their refrigerator via a big box store and using the pick-up option, customers taking their unit to the landfill or recycling station);
- Those participants who decided, based on the incentive provided by the Appliance Recycling program alone, to replace their existing inefficient unit with a new unit. This segment of participants is expected to be very small and documentation of their intentions will be gathered via telephone surveys (i.e., primary data sources). For such customers, the consumption of the new unit should be subtracted from the retired unit consumption and savings claimed for the remaining life of the existing unit. Note that participants who were already planning to replace their unit, and the incentive just ensured that the retired unit was recycled and not placed on the secondary market, should not be included in this adjustment.

This measure was developed to be applicable to the following program types:  ERET.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

n/a

### DEFINITION OF BASELINE EQUIPMENT

The existing inefficient unit must be operational and have a capacity of between 10 and 30 cubic feet.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The estimated remaining useful life of the recycling units is 8 years [500].

### DEEMED MEASURE COST

Measure cost includes the cost of pickup and recycling of the refrigerator and should be based on actual costs of running the program. If unknown assume $120[501] per unit.

---

[500] KEMA "Residential refrigerator recycling ninth year retention study", 2004
[501] Based on similar Efficiency Vermont program.

**DEEMED O&M COST ADJUSTMENTS**

n/a

**LOADSHAPE**

Loadshape R05 - Residential Refrigerator

**COINCIDENCE FACTOR**

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

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

Energy savings are based upon a linear regression model using the following coefficients[502]:

| Variable Description | Coefficient |
| --- | --- |
| Intercept | -633.124 |
| Freezer dummy (=1 if freezer) | 424.019 |
| Side-by-side dummy (= 1 if side-by-side)[503] | -1860.895 |
| Age | 84.281 |
| Age-squared | -0.971 |
| Capacity (Cubic Feet) | 7.895 |
| Manual defrost dummy (= 1 if manual defrost) | -288.297 |
| Side-by-side dummy x Cubic Feet | 108.832 |
| Chest  dummy (= 1 if chest freezer) | -368.380 |

$$\Delta kWh = [-633.124 + (Freezer * 424.019) + (Side * -1860.895) + (Age * 84.281) + (Age^2 * -0.971)$$
$$+ (Capacity * 7.895) + (ManualDefrost * -288.297) + (Side * Capacity * 108.832) + (Chest * -368.380)] * Part\ Use\ Factor$$

Where:

Freezer = Freezer dummy (=1 if freezer, else 0)

Side = Side-by-side dummy (= 1 if side-by-side, else 0)

---

[502] Energy savings are based on an average 30-year TMY temperature of 51.1 degrees.

[503] Although this coefficient is negative, the net partial effect of side-by-side units is positive, given the positive coefficient on the side-by-side and cubic feet interaction (and large average size)

Age                          = Age of retired unit

Capacity                     = Capacity (cubic feet) of retired unit

ManualDefrost    = Manual defrost dummy (= 1 if manual defrost, else 0)

Chest                        = Chest dummy (= 1 if chest freezer, else 0)

Part Use Factor   = To account for those units that are not running throughout the entire year.

= 0.868[504]

For example, a 24 year old, 22 cubic feet, side by side unit with automatic defrost that was located in the kitchen is retired.

$\Delta$kWh     = [-633.124 + (0 * 424.019) + (1 * -1860.895) + (24 * 84.281) + ($24^2$ * -0.971) + (22 * 7.895) + (0 * -288.297) + (1* 22 * 108.832) + (0 * -368.380)] * 0.868

= 1537.4 * 0.868

= 1334 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

Summer Coincident Peak Demand Savings are based upon a linear regression model using the following coefficients:

| Variable | Coefficient |
|---|---|
| Side-by-Side (dummy) | 0.0499 |
| Freezer (dummy) | 0.0208 |
| Age | 0.0115 |
| Age-squared | -0.00014 |
| Capacity (Cubic Feet) | 0.0014 |
| Manual Defrost | -0.044 |
| Garage, Porch or Patio (dummy) | 0.0471 |
| Constant | -0.094 |

$\Delta$kW =   [(Side * 0.0499) + (Freezer * 0.0208) + (Age * 0.0115) + ($Age^2$ * -0.00014) + (Capacity * 0.0014) + (ManualDefrost * -0.044) + (GaragePorchPatio * 0.0471) - 0.094] *Part Use Factor

Where:

---

[504] Weighted average PY2 and PY3 part use factor from Opinion Dynamics, May 4 2012 memo; Fridge & Freezer Recycle Rewards Program PY4 Metering Study: Preliminary Savings Results.

GaragePorchPatio  = Variable based on unit location (=1 if unit in Garage, Porch or Patio, else 0)

Other variables as above

---

For example, a 24 year old, 22 cubic feet, Side by Side unit with automatic defrost that was located in the kitchen is retired.

$$\Delta kW = [(1 * 0.0499) + (0 * 0.0208) + (24 * 0.0115) + (24^2 * -0.00014) + (22 * 0.0014) + (0 * -0.044) + (0 * 0.0471) - 0.094] * 0.868$$

$$= 0.182 * 0.868$$

$$= 0.16 \text{ kW}$$

---

**NATURAL GAS SAVINGS**

n/a

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

n/a

**DEEMED O&M COST ADJUSTMENT CALCULATION**

n/a

**MEASURE CODE: RS-APL-RFRC-V01-060112**

## 7.1.9 Room Air Conditioner Recycling

**DESCRIPTION**

This measure describes the savings resulting from running a drop off service taking existing residential, inefficient Room Air Conditioner units from service, prior to their natural end of life. This measure assumes that though a percentage of these units will be replaced this is not captured in the savings algorithm since it is unlikely that the incentive made someone retire a unit that they weren't already planning to retire. The savings therefore relate to the unit being taken off the grid as opposed to entering the secondary market. The Net to Gross factor applied to these units should incorporate adjustments that account for those participants who would have removed the unit from the grid anyway.

This measure was developed to be applicable to the following program types: ERET.
If applied to other program types, the measure savings should be verified.

**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 LIFETIME OF EFFICIENT EQUIPMENT**

The assumed remaining useful life of the existing room air conditioning unit being retired is 4 years[505].

**DEEMED MEASURE COST**

The actual implementation cost for recycling the existing unit should be used.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R08 - Residential Cooling

**COINCIDENCE FACTOR**

The coincidence factor for this measure is assumed to be 30%[506].

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[505] A third of assumed measure life for Room AC.

[506] 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)

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = ((FLH_{RoomAC} * BtuH * (1/EERexist))/1000)$$

Where:

FLH$_{RoomAC}$      = Full Load Hours of room air conditioning unit

          = dependent on location[507]:

| Climate Zone (City based upon) | FLH$_{RoomAC}$ |
|---|---|
| 1 (Rockford) | 220 |
| 2 (Chicago) | 210 |
| 3 (Springfield) | 319 |
| 4 (Belleville) | 428 |
| 5 (Marion) | 374 |
| Weighted Average[508] | 248 |

Btu/H      = Size of retired unit

          = Actual. If unknown assume 8500 BTU/hour [509]

EERexist      = Efficiency of existing unit

          = 7.7[510]

---

[507] The average ratio of FLH for Room AC (provided 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) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[508] Weighted based on number of residential occupied housing units in each zone.

[509] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[510] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

---

For example for an 8500 BTU/h unit in Springfield:

$$\Delta kWh = ((319 * 8500 * (1/7.7)) / 1000)$$

$$= 352 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

$$CF = \text{Summer Peak Coincidence Factor for measure}$$

$$= 0.3^{511}$$

For example an 8500 BTU/h unit:

$$\Delta kW = (8500 * (1/7.7)) / 1000) * 0.3$$

$$= 0.33 \text{ kW}$$

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-APL-RARC-V01-060112**

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[511] 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%2 0Res%20RAC.pdf)

## 7.2 Consumer Electronics End Use

### 7.2.1 Smart Strip

**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 a 5-plug strip and a 7-plug strip.

This measure was developed to be applicable to the following program types: TOS, NC, DI.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

The efficient case is the use of a 5 or 7-plug smart strip.

**DEFINITION OF BASELINE EQUIPMENT**

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

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The assumed lifetime of the smart strip is 4 years[512].

**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[513].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R13 - Residential Standby Losses – Entertainment
Loadshape R14 - Residential Standby Losses - Home Office

---

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

## COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 80%[514].

---

**Algorithm**

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### CALCULATION OF SAVINGS

### ELECTRIC ENERGY SAVINGS

$$\Delta kWh_{5\text{-Plug}} = 56.5 \text{ kWh }[515]$$

$$\Delta kWh_{7\text{-Plug}} = 103 \text{ kWh }[516]$$

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{Hours} * CF$$

Where:

| | |
|---|---|
| Hours | = Annual number of hours during which the controlled standby loads are turned off by the Smart Strip. |
| | = 7,129 [517] |
| CF | = Summer Peak Coincidence Factor for measure |
| | = 0.8 [518] |

$$\Delta kW_{5\text{-Plug}} = 56.5 / 7129 * 0.8$$

---

[514] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

[515] NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:
   I.   Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
   II.  Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission's PIER Program.
   III. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004. Prepared for California Energy Commission's Public Interest Energy Research (PIER) Program.
   IV.  2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.
   V.   Smart Strip Portfolio of the Future, Navigant Consulting for San Diego G&E, March 31, 2009.

[516] Ibid.

[517] Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips

[518] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

---

$$= 0.00634 \text{ kW}$$

$$\Delta kW_{7\text{-Plug}} = 102.8 / 7129 * 0.8$$

$$= 0.0115 \text{ kW}$$

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-CEL-SSTR-V01-060112**

## 7.3 HVAC End Use

### 7.3.1 Air Source Heat Pump

**DESCRIPTION**

A heat pump provides heating or cooling by moving heat between indoor and outdoor air. This measure involves the installation of a new residential sized (<= 65,000 BTU/hr) air source heat pump that is more efficient than required by federal standards.

This measure was developed to be applicable to the following program types: TOS, NC.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

A new residential sized (<= 65,000 BTU/hr) air source heat pump with specifications to be determined by program.

**DEFINITION OF BASELINE EQUIPMENT**

A new residential sized (<= 65,000 BTU/hr) air source heat pump meeting federal standards.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 18 years[519].

**DEEMED MEASURE COST**

The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit[520]. Note these costs are per ton of unit capacity:

| Efficiency (SEER) | Incremental Cost per Ton of Capacity ($/ton) |
|---|---|
| 14 | 137 |
| 15 | 274 |
| 16 | 411 |
| 17 | 548 |
| 18 | 685 |

**DEEMED O&M COST ADJUSTMENTS**

N/A

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[519] 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
[520] Based on costs derived from DEER 2008 Database Technology and Measure Cost Data
(www.deeresources.com).

LOADSHAPE

Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[521]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[522]

---

**Algorithm**

---

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((FLH\_cooling * Capacity\_cooling * (1/SEER\_base - 1/SEER\_ee)) / 1000) + ((FLH\_heat * Capacity\_heating * (1/HSPF\_base - 1/HSFP\_ee)) / 1000)$$

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location[523]:

| Climate Zone (City based upon) | FLH_cooling (single family) | FLH_cooling (multi family) |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |

---

[521] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[522] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[523] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

| | | |
|---|---|---|
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[524] | 629 | 564 |

Capacity_cooling = Cooling Capacity of Air Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

SEER_base = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)

= 13 [525]

SEER_ee = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

FLH_heat = Full load hours of heating

= Dependent on location[526]:

| Climate Zone (City based upon) | FLH_heat |
|---|---|
| 1 (Rockford) | 1,969 |
| 2 (Chicago) | 1,840 |
| 3 (Springfield) | 1,754 |
| 4 (Belleville) | 1,266 |
| 5 (Marion) | 1,288 |
| Weighted Average[527] | 1,821 |

Capacity_heating = Heating Capacity of Air Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

---

[524] Weighted based on number of occupied residential housing units in each zone.
[525] Based on Minimum Federal Standard;
http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.
[526] Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from http://www.icc.illinois.gov/ags/consumereducation.aspx) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[527] Weighted based on number of occupied residential housing units in each zone.

HSPF_base         =Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)

                  = 7.7 [528]

HSFP_ee           =Heating System Performance Factor of efficient Air Source Heat Pump (kBtu/kWh)

                  = Actual

---

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

$\Delta$kWh    = ((903 * 36,000 * (1/13 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/7.7 - 1/9)) / 1000)

            = 1,203 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta$kW       = (Capacity_cooling * (1/EER_base - 1/EER_ee)) / 1000) * CF

Where:

EER_base        = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/h / kW)

                = 11.2 [529]

EER_ee          = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/h / kW)

                = Actual, If not provided convert SEER to EER using this formula:[530]

                = $(-0.02 * SEER^2) + (1.12 * SEER)$

$CF_{SSP}$         = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

                = 91.5%[531]

$CF_{PJM}$         = PJM Summer Peak Coincidence Factor for Central A/C (average during peak

---

[528] Based on Minimum Federal Standard;
http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.
[529] The Federal Standard does not include an EER requirement, so it is approximated with this formula: (-0.02 * SEER2) + (1.12 * SEER) Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.
[530] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.
[531] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

period)

= 46.6%[532]

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

$\Delta kW_{SSP}$ = ((36,000 * (1/11.2 − 1/12)) / 1000) * 0.915

= 0.196 kW

$\Delta kW_{PJM}$ = ((36,000 * (1/11.2 − 1/12)) / 1000) * 0.466

= 0.100 kW

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-ASHP-V01-060112**

---

[532] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

## 7.3.2 Central Air Conditioning > 14.5 SEER

**DESCRIPTION**

This measure relates to:

a) Time of sale: the installation of a new residential sized (<= 65,000 BTU/hr) Central Air Conditioning ducted split system meeting ENERGY STAR efficiency standards presented below. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.

b) Early replacement: the early removal of an existing residential sized (<= 65,000 BTU/hr) 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.

This measure was developed to be applicable to the following program types:  TOS, NC, EREP.
If applied to other program types, the measure savings should be verified.

**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 for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and 11 EER.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above[533] for the remainder of the measure life.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 18 years [534].

Remaining life of existing equipment is assumed to be 6 years[535].

**DEEMED MEASURE COST**

Time of sale: The incremental capital cost for this measure is dependent on equipment size and efficiency.

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[533] Baseline SEER and EER should be updated when new minimum federal standards become effective.

[534] 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
The "lifespan" of a central air conditioner is about 15 to 20 years (US DOE:
http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440).

[535] Assumed to be one third of effective useful life

Assumed costs per ton of cooling capacity are provided below[536]:

| 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 |
| Average | $530 |

Early replacement: The incremental capital cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume $3,413[537].

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $2,857[538]. This cost should be discounted to present value using the utilities discount rate.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R08 - Residential Cooling

**COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

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[536] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)
[537] Based on 3 ton initial cost estimate for an ENERGY STAR unit from ENERGY STAR Central AC calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls).
[538] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls). While baselines are likely to shift in the future, there is currently no good indication of what the cost of a new baseline unit will be in 6 years. In the absence of this information, assuming a constant federal baseline cost is within the range of error for this prescriptive measure.

= 91.5%[539]

CF$_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[540]

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**Algorithm**

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Time of sale:

ΔkWH = (FLHcool * BtuH * (1/SEERbase - 1/SEERee))/1000

Early replacement[541]:

ΔkWH for remaining life of existing unit (1st 6 years):

=((FLHcool * Capacity * (1/SEERexist - 1/SEERee))/1000);

ΔkWH for remaining measure life (next 12 years):

= ((FLHcool * Capacity * (1/SEERbase - 1/SEERee))/1000)

Where:

FLHcool = Full load cooling hours

= dependent on location and building type[542]:

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[539] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[540] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[541] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

[542] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the

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| Climate Zone (City based upon) | FLHcool (single family) | FLHcool (multi family) |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[543] | 629 | 564 |

Capacity = Size of new equipment in Btuh (note 1 ton = 12,000Btuh)

= Actual installed, or if actual size unknown 33,600Btuh for single-family buildings[544]

SEERbase = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)

= 13[545]

SEERexist = Seasonal Energy Efficiency Ratio of existing unit (kBtu/kWh)

= Use actual SEER rating where it is possible to measure or reasonably estimate. If unknown assume 10.0[546].

SEERee = Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

= Actual installed or 14.5 if unknown

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Time of sale example: a 3 ton unit with SEER rating of 14.5, in unknown location:

$\Delta kWH$ = (629 * 36,000 * (1/13 – 1/14.5)) / 1000

= 180 kWh

---

Appendix providing the appropriate city to use for each county of Illinois.

[543] Weighted based on number of residential occupied housing units in each zone.

[544] Actual unit size required for multi-family building, no size assumption provided because the unit size and resulting savings can vary greatly depending on the number of units.

[545] Based on Minimum Federal Standard;

http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

[546] VEIC estimate based on Department of Energy Federal Standard between 1992 and 2006. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

Early replacement example: a 3 ton unit, with SEER rating of 14.5 replaces an existing unit in unknown location:

$$\Delta kWH \text{(for first 6 years)} = (629 * 36{,}000 * (1/10 - 1/14.5)) / 1000$$

$$= 702 \text{ kWh}$$

$$\Delta kWH \text{(for next 12 years)} = (629 * 36{,}000 * (1/13 - 1/14.5)) / 1000$$

$$= 180 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

Time of sale:

$$\Delta kW = (Capacity * (1/EERbase - 1/EERee))/1000 * CF$$

Early replacement[547]:

ΔkW for remaining life of existing unit (1st 6 years):

$$= ((Capacity * (1/EERexist - 1/EERee))/1000 * CF);$$

ΔkW for remaining measure life (next 12 years):

$$= ((Capacity * (1/EERbase - 1/EERee))/1000 * CF)$$

Where:

| | |
|---|---|
| EERbase | = EER Efficiency of baseline unit |
| | = 11.2 [548] |
| EERexist | = EER Efficiency of existing unit |
| | = Actual EER of unit should be used, if EER is unknown, use 9.2[549] |
| EERee | = EER Efficiency of ENERGY STAR unit |
| | = Actual installed or 12 if unknown |

---

[547] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

[548] The federal Standard does not currently include an EER component. The value is approximated based on the SEER standard (13) and equals EER 11.2. To perform this calculation we are using this formula: (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder).

[549] Based on SEER of 10,0, using formula above to give 9.2 EER.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[550]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[551]

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Time of sale example: a 3 ton unit with EER rating of 12:

$\Delta kW_{SSP}$ = (36,000 * (1/11.2– 1/12)) / 1000 * 0.915

= 0.196 kW

$\Delta kW_{PJM}$ = (36,000 * (1/11.2– 1/12)) / 1000 * 0.466

= 0.100 kW

Early replacement example: a 3 ton unit with EER rating of 12 replaces an existing unit:

$\Delta kW_{SSP}$ (for first 6 years) = (36,000 * (1/9.2– 1/12)) / 1000 * 0.915

= 0.835 kW

$\Delta kW_{SSP}$ (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.915

= 0.196 kW

$\Delta kW_{PJM}$ (for first 6 years) = (36,000 * (1/9.2– 1/12)) / 1000 * 0.466

= 0.425 kW

$\Delta kW_{PJM}$ (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.466

= 0.100 kW

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**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[550] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[551] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-CAC1-V01-060112**

## 7.3.3 Duct Insulation and Sealing

### DESCRIPTION

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system.

Two methodologies for estimating the savings associate from sealing the ducts are provided. The first preferred method requires the use of a blower door and the second requires careful inspection of the duct work.

1.  **Modified Blower Door Subtraction** – this technique is described in detail on p.44 of the Energy Conservatory Blower Door Manual; http://www.energyconservatory.com/download/bdmanual.pdf

2.  **Evaluation of Distribution Efficiency** – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institutes 'Distribution Efficiency Look-Up Table';

    http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

    a.  Percentage of duct work found within the conditioned space

    b.  Duct leakage evaluation

    c.  Duct insulation evaluation

This measure was developed to be applicable to the following program types:  RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is sealed duct work throughout the unconditioned space in the home.

### DEFINITION OF BASELINE EQUIPMENT

The existing baseline condition is leaky duct work within the unconditioned space in the home.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of this measure is 20 years[552].

### DEEMED MEASURE COST

The actual duct sealing measure cost should be used.

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[552] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R08 - Residential Cooling

Loadshape R09 - Residential Electric Space Heat

Loadshape R10 - Residential Electric Heating and Cooling (Shell Measures)

**COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 91.5%[553]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[554]

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

*Methodology 1: Modified Blower Door Subtraction*

a) Determine Duct Leakage rate before and after performing duct sealing:

Duct Leakage ($CFM50_{DL}$)  = ($CFM50_{Whole House}$ – $CFM50_{Envelope Only}$) * SCF

Where:

$CFM50_{Whole House}$  = Standard Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential

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[553] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[554] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

$CFM50_{Envelope\ Only}$ = Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential with all supply and return registers sealed.

SCF = Subtraction Correction Factor to account for underestimation of duct leakage due to connections between the duct system and the home. Determined by measuring pressure in duct system with registers sealed and using look up table provided by Energy Conservatory.

b) Calculate duct leakage reduction, convert to $CFM25_{DL}$ and factor in Supply and Return Loss Factors

Duct Leakage Reduction ($\Delta CFM25_{DL}$) = (Pre $CFM50_{DL}$ – Post $CFM50_{DL}$) * 0.64 * (SLF + RLF)

Where:

0.64 = Converts CFM50 to CFM25[555]

SLF = Supply Loss Factor

= % leaks sealed located in Supply ducts * 1 [556]

Default = 0.5[557]

RLF = Return Loss Factor

= % leaks sealed located in Return ducts * 0.5[558]

Default = 0.25[559]

c) Calculate Energy Savings:

$\Delta kWh_{cooling}$ = (($\Delta CFM25_{DL}$)/ ((Capacity/12,000) * 400)) * FLHcool * Capacity) / 1000 / ηCool

---

[555] 25 Pascals is the standard assumption for typical pressures experienced in the duct system under normal operating conditions. To convert CFM50 to CFM25 you multiply by 0.64 (inverse of the "Can't Reach Fifty" factor for CFM25; see Energy Conservatory Blower Door Manual).

[556] Assumes that for each percent of supply air loss there is one percent annual energy penalty. This assumes supply side leaks are direct losses to the outside and are not recaptured back to the house. This could be adjusted downward to reflect regain of usable energy to the house from duct leaks. For example, during the winter some of the energy lost from supply leaks in a crawlspace will probably be regained back to the house (sometimes 1/2 or more may be regained). More information provided in "Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements" from http://www.energyconservatory.com/download/dbmanual.pdf

[557] Assumes 50% of leaks are in supply ducts.

[558] Assumes that for each percent of return air loss there is a half percent annual energy penalty. Note that this assumes that return leaks contribute less to energy losses than do supply leaks. This value could be adjusted upward if there was reason to suspect that the return leaks contribute significantly more energy loss than "average" (e.g. pulling return air from a super heated attic), or can be adjusted downward to represent significantly less energy loss (e.g. pulling return air from a moderate temperature crawl space) . More information provided in "Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements" from http://www.energyconservatory.com/download/dbmanual.pdf

[559] Assumes 50% of leaks are in return ducts.

Where:

| | |
|---|---|
| $\Delta CFM25_{DL}$ | = Duct leakage reduction in CFM25 |
| | = calculated above |
| Capacity | = Capacity of Air Cooling system (Btu/H) |
| | =Actual |
| 12,000 | = Converts Btu/H capacity to tons |
| 400 | = Converts capacity in tons to CFM (400CFM / ton) |
| FLHcool | = Full load cooling hours |
| | = Dependent on location as below[560]: |

| Climate Zone (City based upon) | FLHcool Single Family | FLHcool Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[561] | 629 | 564 |

| | |
|---|---|
| 1000 | = Converts Btu to kBtu |
| ηCool | = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh) |
| | = Actual. If unknown assume the following[562]: |

| Age of Equipment | SEER Estimate |
|---|---|
| Before 2006 | 10 |
| After 2006 | 13 |

---

[560] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[561] Weighted based on number of occupied residential housing units in each zone.

[562] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, duct sealing in a single family house in Springfield with a 36,000 Btu/H, SEER 11 central air conditioning and the following blower door test results:

Before:  $CFM50_{Whole\ House}$   = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 4500 CFM50

House to duct pressure of 45 Pascals. = 1.29 SCF (Energy Conservatory look up table)

After:   $CFM50_{Whole\ House}$   = 4600 CFM50

$CFM50_{Envelope\ Only}$ = 4500 CFM50

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before}$      = (4800 − 4500) * 1.29

= 387 CFM

$CFM50_{DL\ after}$      = (4600 − 4500) * 1.39

= 139 CFM

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL}$            = (387 − 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

$\Delta kWh_{cooling}$        = ((119 / ((36,000/12,000) * 400)) * 730 * 36,000) / 1000 / 11

= 237 kWh

Heating savings for homes with electric heat (Heat Pump):

$\Delta kWh_{heating}$        = (((\Delta CFM25_{DL} /((Capacity/12,000) * 400)) * FLHheat * Capacity) / \eta Heat / 3412

Where:

FLHheat        = Full load heating hours

= Dependent on location as below[563]:

| Climate Zone (City based upon) | FLH_heat |
|---|---|
| 1 (Rockford) | 1,969 |
| 2 (Chicago) | 1,840 |
| 3 (Springfield) | 1,754 |
| 4 (Belleville) | 1,266 |
| 5 (Marion) | 1,288 |
| Weighted Average[564] | 1,821 |

$\eta$Heat = Efficiency in COP of Heating equipment

= Actual. If not available use[565]:

| 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 |

3412 = Converts Btu to kWh

---

For example, duct sealing in a 36,000 Btu/H 2.5 COP heat pump heated single family house in Springfield with the blower door results described above:

$\Delta$kWh$_{heating}$ = (((119 / ((36,000/12,000) * 400)) * 1,754 * 36,000) / 2.5 / 3412

= 734 kWh

---

***Methodology 2: Evaluation of Distribution Efficiency***

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using Building Performance Institute "Distribution Efficiency Look-Up Table"

$\Delta$kWh$_{cooling}$ = ((DE$_{after}$ – DE$_{before}$)/ DE$_{after}$)) * FLHcool * Capacity)/1000 / $\eta$Cool

---

[563] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.

[564] Weighted based on number of occupied residential housing units in each zone.

[565] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

Where:

$DE_{after}$ = Distribution Efficiency after duct sealing

$DE_{before}$ = Distribution Efficiency before duct sealing

FLHcool = Full load cooling hours

= Dependent on location as below[566]:

| Climate Zone (City based upon) | FLHcool Single Family | FLHcool Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[567] | 629 | 564 |

Capacity = Capacity of Air Cooling system (Btu/H)

= Actual

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual. If unknown assume[568]:

| Age of Equipment | SEER Estimate |
|---|---|
| Before 2006 | 10 |
| After 2006 | 13 |

---

[566] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[567] Weighted based on number of occupied residential housing units in each zone.

[568] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

For example, duct sealing in a single family house in Springfield, with 36,000 Btu/H SEER 11 central air conditioning and the following duct evaluation results:

$DE_{before}$ = 0.85

$DE_{after}$ = 0.92

Energy Savings:

$\Delta kWh_{cooling}$ = ((0.92 – 0.85)/0.92) * 730 * 36,000) / 1000 / 11

= 182 kWh

Heating savings for homes with electric heat (Heat Pump or resistance):

$\Delta kWh_{heating}$ = ((DE$_{after}$ – DE$_{before}$)/ DE$_{after}$)) * FLHheat * Capacity ) / ηHeat / 3412

Where:

FLHheat = Full load heating hours

= Dependent on location as below[569]:

| Climate Zone (City based upon) | FLH_heat |
|---|---|
| 1 (Rockford) | 1,969 |
| 2 (Chicago) | 1,840 |
| 3 (Springfield) | 1,754 |
| 4 (Belleville) | 1,266 |
| 5 (Marion) | 1,288 |
| Weighted Average[570] | 1,821 |

---

[569] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.
[570] Weighted based on number of occupied residential housing units in each zone.

COP               = Coefficient of Performance of electric heating system[571]

                     = Actual. If not available use[572]:

| 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 |

For example, duct sealing in a 36,000 Btu/H, 2.5 COP heat pump heated single family house in Springfield with the following duct evaluation results:

$DE_{after}$             = 0.92

$DE_{before}$           = 0.85

Energy Savings:

$\Delta kWh_{heating}$         = ((0.92 – 0.85)/0.92) * 1,967 * 36,000) / 2.5) / 3412

                            = 632 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW$                = $\Delta kWh_{cooling}$/ FLHcool * CF

Where:

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[571] Note that the HSPF of a heat pump is equal to the COP * 3.413.

[572] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

FLHcool        = Full load cooling hours:

               = Dependent on location as below[573]:

| Climate Zone (City based upon) | FLHcool Single Family | FLHcool Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[574] | 629 | 564 |

$CF_{SSP}$      = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

               = 91.5%[575]

$CF_{PJM}$      = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

               = 46.6%[576]

**NATURAL GAS SAVINGS**

For homes with Natural Gas Heating:

***Methodology 1: Modified Blower Door Subtraction***

ΔTherm         = $((( \Delta CFM25_{DL} / (Capacity * 0.0123)) * FLHheat * Capacity ) / 100{,}000 / \eta Heat$

Where:

$\Delta CFM25_{DL}$     = Duct leakage reduction in CFM25

Capacity       = Capacity of Air Cooling system (Btu/H)

               = Actual

0.0123         = Conversion of Capacity to CFM (0.0123CFM / Btu/h)[577]

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[573] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[574] Weighted based on number of occupied residential housing units in each zone.

[575] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[576] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[577] Based on Natural Draft Furnaces requiring 100 CFM per 10,000 BTU, Induced Draft Furnaces requiring 130CFM

FLHheat     = Full load heating hours

=Dependent on location as below[578]:

| Climate Zone (City based upon) | FLH_heat |
|---|---|
| 1 (Rockford) | 1,969 |
| 2 (Chicago) | 1,840 |
| 3 (Springfield) | 1,754 |
| 4 (Belleville) | 1,266 |
| 5 (Marion) | 1,288 |
| Weighted Average[579] | 1,821 |

100,000     = Converts Btu to therms

ηHeat     = Average Net Heating System Efficiency (Equipment Efficiency * Distribution Efficiency)[580]

= Actual. If not available use 70%[581].

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per 10,000BTU and Condensing Furnaces requiring 150 CFM per 10,000 BTU (rule of thumb from http://contractingbusiness.com/enewsletters/cb_imp_43580/). Data provided by GAMA during the federal rule-making process for furnace efficiency standards, suggested that in 2000, 24% of furnaces purchased in Illinois were condensing units. Therefore a weighted average required airflow rate is calculated assuming a 50:50 split of natural v induced draft non-condensing furnaces, as 123 per 10,000BTU or 0.0123/Btu.

[578] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.

[579] Weighted based on number of occupied residential housing units in each zone.

[580] 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 are more than one heating systems, 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.

[581] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls)) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: (0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

For example, duct sealing in a house in Springfield with an 80% AFUE, 105,000 Btu/H natural gas furnace and the following blower door test results:

Before:  $CFM50_{Whole\ House}$  = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 4500CFM50

House to duct pressure of 45 Pascals = 1.29 SCF (Energy Conservatory look up table)

After:  $CFM50_{Whole\ House}$  = 4600 CFM50

$CFM50_{Envelope\ Only}$ = 4500CFM50

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before}$  = (4800 − 4500) * 1.29

= 387 CFM

$CFM50_{DL\ after}$  = (4600 − 4500) * 1.39

= 119 CFM

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL}$  = (387 − 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

$\Delta Therm$  = ((119/ (105,000 * 0.0123)) * 1,754 * 105,000) / 100,000 / 0.80

= 212 therms

***Methodology 2: Evaluation of Distribution Efficiency***

$\Delta Therm = ((DE_{after} − DE_{before})/ DE_{after})) * FLHheat * Capacity ) / 100,000 / \eta Heat$

Where:

$DE_{after}$  = Distribution Efficiency after duct sealing

$DE_{before}$  = Distribution Efficiency before duct sealing

Other variables as defined above

For example, duct sealing in a house in Springfield an 80% AFUE, 105,000 Btu/H natural gas furnace and the following duct evaluation results:

$DE_{after}$          = 0.92

$DE_{before}$          = 0.85

Energy Savings:

$$\Delta Therm = ((0.92 - 0.85)/0.92) * 1,754 * 105,000) / 100,000 / 0.80$$

$$= 175 \text{ therm}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-DINS-V01-060112**

## 7.3.4  Furnace Blower Motor

### DESCRIPTION

A new furnace with a brushless permanent magnet (BPM) blower motor is installed instead of a new furnace with a lower efficiency motor. This measure characterizes only the electric savings associated with the fan and could be coupled with gas savings associated with a more efficient furnace. Savings decrease sharply with static pressure so duct improvements, and clean, low pressure drop filters can maximize savings. Savings improve when the blower is used for cooling as well and when it is used for continuous ventilation, but only if the non-BPM motor would have been used for continuous ventilation too. If the resident runs the BPM blower continuously because it is a more efficient motor and would not run a non-BPM motor that way, savings are near zero and possibly negative. This characterization uses a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin, which accounted for the effects of this behavioral impact.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

A furnace with a brushless permanent magnet (BPM) blower motor, also known by the trademark ECM, BLDC, and other names.

### DEFINITION OF BASELINE EQUIPMENT

A furnace with a non-BPM blower motor.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years[582].

### DEEMED MEASURE COST

The capital cost for this measure is assumed to be $97[583].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

---

[582] Consistent with assumed life of a new gas furnace. Table 8.3.3 The Technical support documents for federal residential appliance standards:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf
[583] Adapted from Tables 8.2.3 and 8.2.13 in
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/hvac_ch_08_lcc_2011-06-24.pdf

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[584]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[585]

---

**Algorithm**

---

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta$kWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

| | |
|---|---|
| Heating Savings | = Blower motor savings during heating season |
| | = 418 kWh[586] |
| Cooling Savings | = Blower motor savings during cooling season |
| | If Central AC = 263 kWh |
| | If No Central AC = 175 kWh |
| | If unknown (weighted average) |
| | = 241 kWh[587] |

---

[584] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[585] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[586] To estimate heating, cooling and shoulder season savings for Illinois, VEIC adapted results from a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin. This study included effects of behavior change based on the efficiency of new motor greatly increasing the amount of people that run the fan continuously. The savings from the Wisconsin study were adjusted to account for different run hour assumptions (average values used) for Illinois. See: FOE to IL Blower Savings.xlsx.

[587] The weighted average value is based on assumption that 75% of homes installing BPM furnace blower motors

Shoulder Season Savings = Blower motor savings during shoulder seasons

= 51 kWh

For example, a blower motor in a home where Central AC presence is unknown:

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

= 418 +251 + 51

= 721 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = Cooling Savings / FLH_cooling * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[588]:

| Climate Zone (City based upon) | FLH_cooling |
|---|---|
| 1 (Rockford) | 512 |
| 2 (Chicago) | 570 |
| 3 (Springfield) | 730 |
| 4 (Belleville) | 1,035 |
| 5 (Marion) | 903 |
| Weighted Average[589] | 629 |

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[590]

---

have Central AC. 66% of IL housing units have CAC and 66% have gas furnaces. It is logical these two groups overlap to a large extent (like the 95% in the FOE study above).

[588] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[589] Weighted based on number of occupied residential housing units in each zone.

[590] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[591]

---

For example, a blower motor in a home of unknown location where Central AC prevalence is unknown:

$\Delta kW_{SSP}$ = 251 / 629 * 0.915

= 0.365 kW

$\Delta kW_{SSP}$ = 251 / 629 * 0.466

= 0.186 kW

---

**NATURAL GAS SAVINGS**

$\Delta therms$[592] = - Heating Savings * 0.03412 therms/kWh

= - (418 * 0.03412)

= - 14.3 therms[593]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-FBMT-V01-060112**

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[591] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
[592] The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space.
[593] Negative value since this measure will increase the heating load due to reduced waste heat.

## 7.3.5 Gas High Efficiency Boiler

### DESCRIPTION

This measure describes the purchase and installation of a new high efficiency, gas-fired hot water boiler in a residential location. High efficiency boilers achieve most 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.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed Boiler must be ENERGY STAR qualified (AFUE rated at or greater than 85% and input capacity less than 300,000 BTUh).

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment for this measure is a new, gas-fired, standard-efficiency water boiler. The current Federal Standard minimum AFUE rating is 80%. For boilers manufactured after September 2012 the Federal Standards is raised to 82% AFUE.  Baseline assumptions are therefore provided below:

| Program Year | AFUE |
|---|---|
| June 2012 – May 2013[594] | 80% |
| June 2013 on | 82% |

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[595].

### DEEMED MEASURE COST

The incremental cost for this measure is dependent on tier[596]:

| Measure Type | Incr. Cost |
|---|---|
| AFUE 85% (Energy Star Minimum) | $216 |
| AFUE 90% | $422 |
| AFUE 95% | $628 |

---

[594] There will be some delay to the baseline shift while existing stocks of lower efficiency equipment is sold.
[595] Table 8.3.3 The Technical support documents for federal residential appliance standards:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf
[596] Appliance Standards Technical Support Documents
(http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html). Note this assumes the baseline of 80% and should be reevaluated when new information is available for the new baseline.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

## Algorithm

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS SAVINGS**

$$\Delta Therms = Gas\_Boiler\_Load * (1/AFUE(base) - 1/AFUE(eff))$$

Where:

Gas_Boiler_Load[597]

= Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below[598].

= or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[599].

---

[597] Boiler consumption values are informed by an evaluation which did not identify any fraction of heating load due to domestic hot water (DHW) provided by the boiler. Thus these values are an average of both homes with boilers only providing heat, and homes with boilers that also provide DHW. Heating load is used to describe the household heating need, which is equal to (gas heating consumption * AFUE )

[598] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*). Adjusting to a statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

[599] The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8th Edition produces equipment sizing loads for Single Family, Multi-single, and Condominiums using input characteristics of the home. A best practice for equipment selection and installation of Heating and Air Conditioning, load calculations should

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| Climate Zone (City based upon) | Gas_Boiler Load (therms) |
|---|---|
| 1 (Rockford) | 1275 |
| 2 (Chicago) | 1218 |
| 3 (Springfield) | 1043 |
| 4 (Belleville) | 805 |
| 5 (Marion) | 819 |
| Average | 1158 |

AFUE(base)     = Baseline Boiler Annual Fuel Utilization Efficiency Rating

= Dependent on year as listed below:

| Program Year | AFUE(base) |
|---|---|
| June 2012 – May 2013 | 80% |
| June 2013 on | 82% |

AFUE(eff)     = Efficent Boiler Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, use defaults dependent[600] on tier as listed below:

| Measure Type | AFUE(eff) |
|---|---|
| ENERGY STAR® | 87.5% |
| AFUE 90% | 92.5% |
| AFUE 95% | 95% |

For example, a default sized ENERGY STAR boiler purchased and installed near Springfield in the year 2012

ΔTherms          = (1043) * (1/0.8) - 1/0.875)

= 112 Therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-GHEB-V01-060112**

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be completed by contractors during the selection process and may be readily available for program data purposes.
[600] Default values per tier selected based upon the average AFUE value for the tier range except for the top tier where the minimum is used due to proximity to the maximum possible.

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## 7.3.6  Gas High Efficiency Furnace

### DESCRIPTION

This measure covers the purchase of a new ENERGY STAR-qualified high efficiency gas-fired condensing furnace for residential space heating in place of a new Federal Standard furnace. High efficiency features may include improved heat exchangers and modulating multi-stage burners.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a residential sized (input energy less than 225,000 BTUh) ENERGY STAR rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency in accordance with ENERGY STAR criteria[601], as defined below:

| ENERGY STAR Furnaces Specification | Min. AFUE | Min. Fan Efficiency[602] | Max. Air Leakage |
|---|---|---|---|
| Version 2.0 – Effective until 2.1.12 | 90% | N/A | N/A |
| Version 3.0 – Effective 2.1.12 | 95% | 2.0% | N/A |
| Version 4.0 – Effective 2.1.13 | 95% | 2.0% | 2.0% |

### DEFINITION OF BASELINE EQUIPMENT

Although the current Federal Standard for gas furnaces is an AFUE rating of 78%, based upon review of available product in the AHRI database, the baseline efficiency for this characterization is assumed to be 80% for program year June 2012 – May 2013.

For furnaces manufactured after September 2012 the Federal minimum efficiency Standards are raised to 90% AFUE. Baseline assumptions are therefore provided below:

| Program Year | AFUE |
|---|---|
| June 2012 – May 2013 | 80% |
| June 2013 on | 90% |

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years[603].

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[601] Source: Final Furnace Version3.0/4.0 Specification schedules available here:
http://www.energystar.gov/index.cfm?c=revisions.furnace_spec
[602] Fan efficiency, as determined by the "Interim Approach for Determining Furnace Fan Energy Use Rev. June-2011" is a performance-based metric that was  designed to function in a manner that resembles past program criteria requiring an ECM or BPM fan motor.
[603] Table 8.3.3 The Technical support documents for federal residential appliance standards:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf

**DEEMED MEASURE COST**

The incremental capital cost for this measure depends on efficiency as listed below[604]:

| AFUE | Incremental Cost (June 2012 – May 2013) | Incremental Cost (June 2013 on) |
|---|---|---|
| 90% | $304 | $0 |
| 91% | $394 | $90 |
| 92% | $477 | $173 |
| 93% | $567 | $263 |
| 94% | $657 | $353 |
| 95% | $754 | $450 |
| 96% | $851 | $547 |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

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## Algorithm

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Electrical energy savings from the more fan-efficient (typically using brushless permanent magnet (BPM) blower motor) should also be claimed, please refer to "Furnace Blower Motor" characterization for details.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

If the blower motor is also used for cooling, coincident peak demand savings should also be claimed, please refer to "Furnace Blower Motor" characterization for savings details.

**NATURAL GAS SAVINGS**

ΔTherms = Gas_Furnace_Heating_Load * (1/AFUE(base) - 1/AFUE(eff))

Where:

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[604] Appliance Standards Technical Support Documents (http://www1.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html )

Gas_Furnace_Heating_Load

= Estimate of annual household heating load [605] for gas furnace heated single-family homes. If location is unknown, assume the average below[606].

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[607].

| Climate Zone (City based upon) | Gas_Furnace_Heating_Load (therms) |
|---|---|
| 1 (Rockford) | 843 |
| 2 (Chicago) | 806 |
| 3 (Springfield) | 690 |
| 4 (Belleville) | 532 |
| 5 (Marion) | 542 |
| Average | 766 |

AFUE(base)　　　= Baseline Furnace Annual Fuel Utilization Efficiency Rating

= Dependent on year as listed below[608]:

| Program Year | AFUE(base) |
|---|---|
| June 2012 – May 2013 | 80% |
| June 2013 on | 90% |

AFUE(eff)　　　= Efficent Furnace Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, assume 95%[609]

---

[605] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE )
[606] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*) Adjusting to a statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.
[607] The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8th Edition produces equipment sizing loads for Single Family, Multi-single, and Condominiums using input characteristics of the home. A best practice for equipment slection and installation of Heating and Air Conditioning, load calculations are commonly completed by contractors during the selection process and may be readily available for program data purposes.
[608] Though the Federal Minimum AFUE is 78%, there were only 50 models listed in the AHRI database at that level. At AFUE 79% the total rises to 308. There are 3,548 active furnace models listed with AFUE ratings between 78 and 80.
[609] Minimum ENERGY STAR efficiency after 2.1.2012.

For example, a 95% AFUE furnace near Rockford and purchased in the year 2012

ΔTherms = 843 * (1/0.8 - 1/0.95)

=166 therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-GHEF-V01-060112**

## 7.3.7   Ground Source Heat Pump

### DESCRIPTION

This measure relates to the installation of a new Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below.

ENERGY STAR Requirements (Effective January 1, 2012)

| 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 |

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### 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 LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years[610].

### 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[611].

---

[610] Lifetime for an air source heat pump. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. The more moderate operating conditions for a GSHP may extend the life of these components beyond the life of an ASHP. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf
[611] 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

**LOADSHAPE**

Loadshape R10 - Residential Electric Heating and Cooling

**COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[612]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[613]

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$\Delta kWh$ = (FLHcool * Btu/H * (1/SEERbase – (1/(EERee * 1.02))/1000 + (FLHheat * Btu/H * (1/HSPFbase – (1/COPee * 3.412))/1000

Where:

FLHcool = Full load cooling hours

---

[612] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[613] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

---

Dependent on location as below[614]:

| Climate Zone (City based upon) | FLHcool Single Family | FLHcool Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[615] | 629 | 564 |

Btu/H          = Size of equipment in Btu/h (note 1 ton = 12,000Btu/h)

               = Actual installed

SEERbase       = SEER Efficiency of baseline ASHP unit

               = 13 [616]

EERee          = EER Efficiency of efficient GSHP unit

               = Actual installed

1.02           = Constant used to estimate the equivalent air conditioning SEER based on the GSHP unit's EER[617].

---

[614] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[615] Weighted based on number of occupied residential housing units in each zone.

[616] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

[617] 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 VEIC extrapolation of manufacture data.

FLHheat = Full load heating hours

Dependent on location as below[618]:

| Climate Zone (City based upon) | FLH_heat |
|---|---|
| 1 (Rockford) | 1,969 |
| 2 (Chicago) | 1,840 |
| 3 (Springfield) | 1,754 |
| 4 (Belleville) | 1,266 |
| 5 (Marion) | 1,288 |
| Weighted Average[619] | 1,821 |

HSPFbase =Heating Season Performance Factor for baseline unit

=7.7 [620]

COPee = Coefficient of Performance of efficient unit

= Actual Installed

3.412 = 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 single family house in Springfield:

ΔkWh = (FLHcool * Btu/H * (1/SEERbase – (1/(EERee * 1.02))/1000+ (FLHheat * Btu/H * ( 1/HSPFbase – (1/COPee * 3.412))/1000

ΔkWh = (730 * 36,000 * (1/13 – 1/ (16*1.02))) / 1000 + (1967 * 36,000 * (1/7.7 – 1/ (3.5*3.412)) / 1000

= 3680 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = (Btu/H * (1/EERbase - 1/EERee$_{AC\ equivalent}$))/1000) * CF

Where:

EERbase = EER Efficiency of baseline ASHP unit

---

[618] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[619] Weighted based on number of occupied residential housing units in each zone.
[620] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

$= 11$ [621]

$EERee_{AC\ equivalent}$     = Equivalent Air Conditioning EER Efficiency of ENERGY STAR GSHP unit[622]

To calculate this, the actual EER of the GSHP is converted to an air conditioning SEER equivalent by multiplying by 1.02 [623]

This is then converted to the air conditioning EER equivalent resulting in the following algorithm:

$EERee_{AC\ equivalent} = (-0.02 * (EERee * 1.02)^2 + (1.12 * (EERee * 1.02))$ [624]

$CF_{SSP}$     = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

$= 91.5\%$ [625]

$CF_{PJM}$     = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

$= 46.6\%$ [626]

---

For example, a 3 ton unit with EER rating of 16:

$$\Delta kW_{SSP} = ((36{,}000 * (1/11 - 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.915$$

$$= 0.451\ kW$$

$$\Delta kW_{SSP} = ((36{,}000 * (1/11 - 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466$$

$$= 0.230\ kW$$

---

**NATURAL GAS SAVINGS**

N/A

---

[621] Minimum Federal Standard; as above.

[622] EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures).

[623] Based on VEIC extrapolation of manufacturer data.

[624] Air conditioning SEER to EER algorithm based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[625] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[626] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-GSHP-V01-060112**

## 7.3.8    High Efficiency Bathroom Exhaust Fan

### DESCRIPTION

This market opportunity is defined by the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell.  In retrofit projects, existing fans may be too loud, or insufficient in other ways, to be operated as required for proper ventilation. This measure assumes a fan capacity of 50 CFM rated at a sound level of less than 2.0 sones at 0.1 inches of water column static pressure.   This measure may be applied to larger capacity, up to 130 CFM, efficient fans with bi-level controls because the savings and incremental costs are very similar. All eligible installations shall be sized to provide the mechanical ventilation rate indicated by ASHRAE 62.2.

This measure was developed to be applicable to the following program types:  TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

New efficient (average CFM/watt of  8.3 [627]) exhaust-only ventilation fan, quiet (< 2.0 sones) Continuous operation in accordance with recommended ventilation rate indicated by ASHRAE 62.2[628]

### DEFINITION OF BASELINE EQUIPMENT

New standard efficiency (average CFM/Watt of 3.1[629]) exhaust-only ventilation fan, quiet (< 2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2 [630]

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 19 years[631].

### DEEMED MEASURE COST

Incremental cost per installed fan is $43.50 for quiet, efficient fans[632].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R11 - Residential Ventilation

---

[627] VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.
[628] Bi-level controls may be used by efficient fans larger than 50 CFM
[629] VEIC analysis looking at average baseline fan (i.e. non-Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.
[630] On/off cycling controls may be required of baseline fans larger than 50CFM.
[631] Conservative estimate based upon GDS Associates Measure Life Report "Residential and C&I Lighting and HVAC measures" 25 years for whole-house fans, and 19 for thermostatically-controlled attic fans.
[632] VEIC analysis using cost data collected from wholesale vendor; http://www.westsidewholesale.com/ .

### COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 100% because the fan runs continuously.

---

**Algorithm**

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### CALCULATION OF SAVINGS

### ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (CFM * (1/\eta_{,BASELINE} - 1/\eta_{EFFICIENT})/1000) * Hours$$

Where:

| | |
|---|---|
| CFM | = Nominal Capacity of the exhaust fan |
| | = 50 CFM[633] |
| $\eta_{BASELINE}$ | = Average efficacy for baseline fan |
| | = 3.1 CFM/Watt[634] |
| $\eta_{EFFCIENT}$ | = Average efficacy for efficient fan |
| | = 8.3 CFM/Watt[635] |
| Hours | = assumed annual run hours, |
| | = 8766 for continuous ventilation. |

$$\Delta kWh = (50 * (1/3.1 – 1/8.3)/1000) * 8766$$

$$= 88.6 \text{ kWh}$$

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (CFM * (1/\eta_{BASELINE} - 1/\eta_{EFFICIENT})/1000) * CF$$

Where:

---

[633] 50CFM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedrooms.
[634] VEIC analysis looking at average baseline fan (i.e. non-Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.
[635] VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.

CF                          = Summer Peak Coincidence Factor

                            = 1.0 (continuous operation)

                            Other variables as defined above

ΔkW      = (50 * (1/3.1 – 1/8.3)/1000) * 1.0

            = 0.0101 kW

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-BAFA-V01-060112**

## 7.3.9   HVAC Tune Up (Central Air Conditioning or Air Source Heat Pump)

### 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 Illinois to generate a more locally appropriate characterization.

This measure was developed to be applicable to the following program types:  RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

N/A

### DEFINITION OF BASELINE EQUIPMENT

This measure assumes that the existing unit being maintained is either a residential central air conditioning unit or an air source heat pump that has not been serviced for at least 3 years.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

THE MEASURE LIFE IS ASSUMED TO BE 2 YEARS[636].

### 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 $175[637].

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R08 - Residential Cooling

### COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid

---

[636] Based on VEIC professional judgment.
[637] Based on personal communication with HVAC efficiency program consultant Buck Taylor or Roltay Inc., 6/21/10, who estimated the cost of tune up at $125 to $225, depending on the market and the implementation details.

into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 91.5%[638]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[639]

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$\Delta kWh_{Central\ AC}$ = (FLHcool * Capacity_cooling* (1/SEER$_{CAC}$))/1000 * MFe

$\Delta kWh_{Air\ Source\ Heat\ Pump}$ = ((FLHcool * Capacity_cooling * (1/SEER$_{ASHP}$))/1000  * MFe) + (FLHheat * Capacity_heating * (1/HSPF$_{ASHP}$))/1000 * MFe)

Where:

FLHcool = Full load cooling hours

Dependent on location as below:[640]

| Climate Zone (City based upon) | FLHcool Single Family | FLHcool Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[641] | 629 | 564 |

---

[638] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[639] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[640] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[641] Weighted based on number of occupied residential housing units in each zone.

Capacity_cooling = Cooling cpacity of equipment in Btu/h (note 1 ton = 12,000 Btu/h)

= Actual

$SEER_{CAC}$ = SEER Efficiency of existing central air conditioning unit receiving maintenence

= Actual. If unknown assume 10 SEER [642]

MFe = Maintenance energy savings factor

= 0.05[643]

$SEER_{ASHP}$ = SEER Efficiency of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 10 SEER [644]

FLHheat = Full load heating hours

Dependent on location:[645]

| Climate Zone (City based upon) | FLHheat |
|---|---|
| 1 (Rockford) | 2208 |
| 2 (Chicago) | 2064 |
| 3 (Springfield) | 1967 |
| 4 (Belleville) | 1420 |
| 5 (Marion) | 1445 |
| Weighted Average[646] | 1821 |

Capacity_heating = Heating cpacity of equipment in Btu/h (note 1 ton = 12,000 Btu/h)

= Actual

---

[642] Use actual SEER rating where it is possible to measure or reasonably estimate. Unknown default of 10 SEER is a VEIC estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006.
[643] Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."
[644] Use actual SEER rating where it is possible to measure or reasonably estimate. Unknown default of 10 SEER is a VEIC estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006.
[645] Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from http://www.icc.illinois.gov/ags/consumereducation.aspx) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[646] Weighted based on number of occupied residential housing units in each zone.

---

HSPFbase = Heating Season Performance Factor of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 6.8 HSPF [647]

---

For example, maintenance of a 3-ton, SEER 10 air conditioning unit in a single family house in Springfield:

$\Delta kWh_{CAC}$ = (730 * 36,000 * (1/10))/1000 * 0.05

= 131 kWh

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

$\Delta kWh_{ASHP}$ = ((730 * 36,000 * (1/10))/1000 * 0.05) + (1967 * 36,000 * (1/6.8))/1000 * 0.05)

= 652 kWh

---

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW$ **=** Capacity_cooling * (1/EER)/1000 * MFd * CF

Where:

EER = EER Efficiency of existing unit receiving maintenance in Btu/H/Watts

= Calculate using Actual SEER

= $- 0.02 * SEER^2 + 1.12 * SEER$ [648]

MFd = Maintenance demand savings factor

= 0.02 [649]

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5% [650]

---

[647] Use actual HSPF rating where it is possible to measure or reasonably estimate. Unknown default of 6.8 HSPF is a VEIC estimate based on minimum Federal Standard between 1992 and 2006.

[648] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[649] Based on June 2010 personal conversation with Scott Pigg, author of Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research" suggesting the average WI unit system draw of 2.8kW under peak conditions, and average peak savings of 50W.

[650] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[651]

---

For example, maintenance of 3-ton, SEER 10 (equals EER 9.2) unit:

$\Delta kW_{SSP}$ = 36,000 * 1/(9.2)/1000 * 0.02 * 0.915

= 0.0716 kW

$\Delta kW_{PJM}$ = 36,000 * 1/(9.2)/1000 * 0.02 * 0.466

= 0.0365 kW

---

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

Conservatively not included

**MEASURE CODE: RS-HVC-TUNE-V01-060112**

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during the utility's peak hour is divided by the maximum AC load during the year.

[651] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

## 7.3.10 Programmable Thermostats

### DESCRIPTION

This measure characterizes the household energy savings from the installation of a Programmable Thermostat for reduced heating energy consumption through temperature set-back during unoccupied or reduced demand times. Because a literature review was not conclusive in providing a defensible source of prescriptive cooling savings from programmable thermostats, cooling savings from programmable thermostats are assumed to be zero for this version of the measure. It is not appropriate to assume a similar pattern of savings from setting a thermostat down during the heating season and up during the cooling season.  Note that the EPA's EnergyStar program is developing a new specification for this project category, and if/when evaluation results demonstrate consistent cooling savings, subsequent versions of this measure will revisit this assumption[652].

This measure was developed to be applicable to the following program types:  TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure are established by replacement of a manual-only temperature control, with one that has the capability to adjust temperature setpoints according to a schedule without manual intervention. This category of equipment is broad and rapidly advancing in regards to the capability, and usability of the controls and their sophistication in setpoint adjustment and information display, but for the purposes of this characterization, eligibility is perhaps most simply defined by what it isn't: a manual only temperature control.

### DEFINITION OF BASELINE EQUIPMENT

Non-Programmable Thermostat requiring manual intervention to change temperature setpoint.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[653] based upon equipment life only[654]. This is reduced by a 50% persistence factor to give final measures life of 5 years.

### DEEMED MEASURE COST

Actual material and labor costs should be used if the implementation method allows. If unknown (e.g. through a retail program) the capital cost for this measure is assumed to be $30[655].

---

[652] The EnergyStar program discontinued its support for this measure category effective 12/31/09, and is presently developing a new specification for 'Residential Climate Controls'.

[653] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[654] Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption.  As this characterization depends heavily upon a large scale but only 2-year study of the energy impacts of programmable thermostats, the longer term impacts should be assessed.

[655] Market prices vary significantly in this category, generally increasing with thermostat capability and sophistication.  The basic functions required by this measure's eligibility criteria are available on units readily available in the market for the listed price.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R09 - Residential Electric Space Heat

**COINCIDENCE FACTOR**

N/A due to no savings attributable to cooling during the summer peak period.

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh[656]  = %ElectricHeat * Elec_Heating_Consumption * Heating_Reduction * HF * Eff_ISR + (ΔTherms * $F_e$ * 29.3)

Where:

%ElectricHeat  = Percentage of heating savings assumed to be electric

| Heating fuel | %ElectricHeat |
|--------------|---------------|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 13%[657] |

Elec_Heating_ Consumption

= Estimate of annual household heating consumption for electrically heated single-family homes[658]. If location and heating type is unknown, assume 17,734 kWh[659]

---

[656] Note the second part of the algorithm relates to furnace fan savings if the heating system is Natural Gas.
[657] Average (default) value of 13% electric space heating from 2010 Residential Energy Consumption Survey for Illinois. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.
[658] Values in table are based on converting an average household heating consumption (849 therms) for Chicago based on 'Table 3-4, Program Sample Analysis, Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor', to an electric heat consumption (divide by 0.03413 and assuming efficiencies of 100% for resistance and 200% for HP) and then adjusting to a statewide average using relative HDD assumptions to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

---

| Climate Zone (City based upon) | Electric Resistance Elec_Heating_ Consumption (kWh) | Electric Heat Pump Elec_Heating_ Consumption (kWh) |
|---|---|---|
| 1 (Rockford) | 26,038 | 13,019 |
| 2 (Chicago) | 24,875 | 12,438 |
| 3 (Springfield) | 21,304 | 10,652 |
| 4 (Belleville) | 16,434 | 8,217 |
| 5 (Marion) | 16,726 | 8,363 |
| Average | 23,645 | 11,822 |

Heating_Reduction = Assumed percentage reduction in heating energy consumption due to programmable thermostat

= 6.2%[660]

HF = Household factor, to adjust heating consumption for non-single-family households.

| Household Type | HF |
|---|---|
| Single-Family | 100% |
| Multi-Family | 65%[661] |
| Actual | Custom[662] |

Eff_ISR = Effective In-Service Rate, the percentage of thermostats installed and programmed effectively

| Program Delivery | Eff_ISR |
|---|---|
| Direct Install | 100% |
| Other, or unknown | 56%[663] |

---

[659] Assumption that 1/2 of electrically heated homes have electric resistance and 1/2 have Heat Pump, based on 2010 Residential Energy Consumption Survey for Illinois.

[660] The savings from programmable thermostats are highly susceptible to many factors best addressed, so far for this category, by a study that controlled for the most significant issues with a very large sample size. To the extent that the treatment group is representative of the program participants for IL, this value is suitable. Higher and lower values would be justified based upon clear dissimilarities due to program and product attributes. Future evaluation work should assess program specific impacts associated with penetration rates, baseline levels, persistence, and other factors which this value represents.

[661] Multifamily household heating consumption relative to single-family households is affected by overall household square footage and exposure to the exterior. This 65% reduction factor is applied to MF homes with electric resistance, based on professional judgment that average household size, and heat loads of MF households are smaller than single-family homes

[662] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

[663]"Programmable Thermostats. Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness," GDS Associates, Marietta, GA. 2002GDS

| | |
|---|---|
| ΔTherms | = Therm savings if Natural Gas heating system |
| | = See calculation in Natural Gas section below |
| $F_e$ | = Furnace Fan energy consumption as a percentage of annual fuel consumption |
| | = 3.14%[664] |
| 29.3 | = kWh per therm |

For example, a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield:

ΔkWH　= 1 * 20,214* 0.062 * 100% * 100% + (0 * 0.0314 * 29.3)

　　　　= 1253 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A due to no savings from cooling during the summer peak period.

**NATURAL GAS ENERGY SAVINGS**

ΔTherms  = %FossilHeat * Gas_Heating_Consumption * Heating_Reduction * HF * Eff_ISR

Where:

%FossilHeat　　= Percentage of heating savings assumed to be Natural Gas

| Heating fuel | %FossilHeat |
|---|---|
| Electric | 0% |
| Natural Gas | 100% |
| Unknown | 87%[665] |

Gas_Heating_Consumption

= Estimate of annual household heating consumption for gas heated single-family homes. If location is unknown, assume the average below[666].

---

[664] $F_e$ is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBTU/yr) and Eae (kWh/yr).  An average of a 300 record sample (non-random) out of 1495 was 3.14%.  This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% $F_e$. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[665] Average (default) value of 87% electric space heating from 2010 Residential Energy Consumption Survey for Illinois. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[666] Values are based on adjusting the average household heating consumption (849 therms) for Chicago based on 'Table 3-4, Program Sample Analysis, Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor'

| Climate Zone (City based upon) | Gas_Heating_ Consumption (therms) |
|---|---|
| 1 (Rockford) | 889 |
| 2 (Chicago) | 849 |
| 3 (Springfield) | 727 |
| 4 (Belleville) | 561 |
| 5 (Marion) | 571 |
| Average | 807 |

For example, a programmable thermostat directly-installed in a gas heated single-family home in Chicago:

ΔTherms = 1.0 * 849* 0.062 * 100% * 100%

= 52.6 therms

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HVC-PROG-V01-060112**

adjusting to a statewide average using relative HDD assumptions to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

## 7.4   Hot Water End Use

### 7.4.1   Domestic Hot Water Pipe Insulation

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. This is the most cost effective section to insulate since the water pipes act as an extension of the hot water tank up to the first elbow which acts as a heat trap. Insulating this length therefore helps reduce standby losses. Default savings are provided per 3ft length and are appropriate up to 6ft of the hot water pipe and 3ft of the cold.

This measure was developed to be applicable to the following program types:  TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is installing pipe wrap insulation to a length of hot water pipe.

DEFINITION OF BASELINE EQUIPMENT

The baseline is an un-insulated hot water pipe.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15 years[667].

DEEMED MEASURE COST

The measure cost including material and installation is assumed to be $3 per linear foot[668].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

This measure assumes a flat loadshape since savings relate to reducing standby losses and as such the coincidence factor is 1.

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[667] 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
[668] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

For electric DHW systems:

$$\Delta kWh = ((1/R_{exist} - 1/R_{new}) * (L * C) * \Delta T * 8{,}766)/ \eta DHW / 3413$$

Where:

| | |
|---|---|
| $R_{exist}$ | = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu] |
| | = 1.0[669] |
| $R_{new}$ | = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft)/Btu] |
| | = Actual (1.0 + R value of insulation) |
| L | = Length of pipe from water heating source covered by pipe wrap (ft) |
| | = Actual |
| C | = Circumference of pipe (ft) (Diameter (in) * $\pi$/12) |
| | = Actual (0.5" pipe = 0.131ft, 0.75" pipe = 0.196ft) |
| $\Delta T$ | = Average temperature difference between supplied water and outside air temperature (°F) |
| | = 60°F [670] |
| 8,766 | = Hours per year |
| $\eta DHW$ | = Recovery efficiency of electric hot water heater |
| | = 0.98 [671] |
| 3412 | = Conversion from Btu to kWh |

---

[669] Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", p77.
[670] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.
[671] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

$$\Delta kWh = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 3412$$

$$= ((1/1 - 1/5) * (5 * 0.196) * 60 * 8766) / 0.98 / 3412$$

$$= 123 \text{ kWh}$$

If inputs above are not available the following default per 3ft R-5 length can be used for up to 6 ft length on the hot pipe and 3 ft on the cold pipe.

$$\Delta kWh = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 3412$$

$$= ((1/1 - 1/5) * (3 * 0.196) * 60 * 8766) / 0.98 / 3412$$

$$= 74.0 \text{ kWh per 3ft length}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = \Delta kWh / 8766$$

Where:

ΔkWh = kWh savings from pipe wrap installation

8766 = 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-5 wrap:

$$\Delta kW = 123/8766$$

$$= 0.014 kW$$

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6 ft length on the hot pipe and 3 ft on the cold pipe.

$$\Delta kW = 73.9/8766$$

$$= 0.0084 \text{ kW}$$

**NATURAL GAS SAVINGS**

For Natural Gas DHW systems:

$$\Delta Therm = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 100{,}000$$

Where:

ηDHW = Recovery efficiency of gas hot water heater

= 0.78 [672]

Other variables as defined above

---

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

ΔTherm = ((1/1– 1/5) * (5 * 0.196) * 60 * 8766) / 0.78 / 100,000

= 5.29 therms

---

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6ft length on the hot pipe and 3ft on the cold pipe.

ΔTherm = ((1/Rexist – 1/Rnew) * (L * C) * ΔT * 8,766) / ηDHW / 100,000

= ((1/1– 1/5) * (3 * 0.196) * 60 * 8766) / 0.78 /100,000

= 3.17 therms per 3ft length

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-PINS-V01-060112**

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[672] 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 78%

## 7.4.2   Gas Water Heater

### DESCRIPTION

This measure characterizes the purchase and installation of a new efficient gas-fired water heater, in place of a Federal Standard unit in a residential setting. Savings are provided for power-vented, condensing storage, and whole-house tankless units meeting specific EF criteria.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the efficient equipment must be a water heater rated with the following minimum efficiency ratings:

| Water heater Type | Minimum Energy Factor |
|---|---|
| Gas Storage | 0.67 |
| Condensing gas storage | 0.80 |
| Tankless whole-house unit | 0.82 |

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard gas storage water heater of the same capacity as the efficient unit, rated at the federal minimum (0.67 – 0.0019 * storage size in gallons)[673]. For a 40-gallon storage water heater this would be 0.594 EF.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years[674].

---

[673] Federal Standard as of January 2004,
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf
[674] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf  Note: This source is used to support this category in aggregate.  For all water heaters, life expectancy will depend on local variables such as water chemistry and homeowner maintenance. Some categories, including condensing storage and tankless water heaters do not yet have sufficient field data to support separate values.  Preliminary data show lifetimes may exceed 20 years, though this has yet to be sufficiently demonstrated.

**DEEMED MEASURE COST**

The incremental capital cost for this measure is dependent on the type of water heater as listed below[675]:

| Water heater Type | Incremental Cost |
|---|---|
| Gas Storage | $400 |
| Condensing gas storage | $685 |
| Tankless whole-house unit | $605 |

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$\Delta$Therms = (1/ $EF_{BASE}$ - 1/$EF_{EFFICIENT}$) * (GPD * 365.25 * $\gamma$Water * ($T_{OUT} - T_{IN}$) * 1.0 )/100,000

Where:

---

[675] Source for cost info; DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf)

EF_Baseline = Energy Factor rating for baseline equipment

= $(0.67 - 0.0019 * \text{tank\_size})$ [676]

| Tank_size (gallons) | EF_Baseline |
|---|---|
| 40 | 0.594 |
| 50 | 0.575 |
| 60 | 0.556 |

= If tank size unknown assume 40 gallons and EF_Baseline of 0.594

EF_Efficient = Energy Factor Rating for efficient equipment

= Actual. If Tankless whole-house multiply rated efficiency by 0.91[677]. If unknown assume values in look up in table below

| Water Heater Type | EF_Efficient |
|---|---|
| Condensing Gas Storage | 0.80 |
| Gas Storage | 0.67 |
| Tankless whole-house | 0.82 * 0.91 = 0.75 |

GPD = Gallons Per Day of hot water use per household

= 50 [678]

365.25 = Days per year, on average

γWater = Specific Weight of water

= 8.33 pounds per gallon

$T_{OUT}$ = Tank temperature

---

[676] Algorithm based on current Federal Standard;
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf
Note that changes to the Federal Standard will be applied from April 16, 2015, see link below for more details:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/heating_products_fr.html.
[677] The disconnect between rated energy factor and in-situ energy consumption is markedly different for tankless units due to significantly higher contributions to overall household hot water usage from short draws. In tankless units the large burner and unit heat exchanger must fire and heat up for each draw. The additional energy losses incurred when the mass of the unit cools to the surrounding space in-between shorter draws was found to be 9% in a study prepared for Lawrence Berkeley National Laboratory by Davis Energy Group, 2006. "Field and Laboratory Testing of Tankless Gas Water Heater Performance" Due to the similarity (storage) between the other categories and the baseline, this derating factor is applied only to the tankless category.
[678] Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions,"
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

$$= 125°F$$

$T_{IN}$ = Incoming water temperature from well or municipal system

$$= 54°F[679]$$

1.0 = Heat Capacity of water (1 Btu/lb*°F)

---

For example, a 40 gallon condensing gas storage water heater, with an energy factor of 0.80:

ΔTherms = (1/0.594) - 1/0.8) * (50 * 365.25* 8.33 * (125 – 54) * 1) / 100,000

= 46.8 therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-GWHT-V01-060112**

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[679] US DOE Building America Program. Building America Analysis Spreadsheet.  For Chicago, IL
http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

## 7.4.3   Heat Pump Water Heaters

**DESCRIPTION**

The installation of a heat pump domestic hot water heater in place of a standard electric water heater in a home. Savings are presented dependent on the heating system installed in the home due to the impact of the heat pump water heater on the heating loads.

This measure was developed to be applicable to the following program types:  TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

**DEFINITION OF EFFICIENT EQUIPMENT**

To qualify for this measure the installed equipment must be a Heat Pump domestic water heater.

**DEFINITION OF BASELINE EQUIPMENT**

The baseline condition is assumed to be a new electric water heater meeting federal minimum efficiency standards.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 13 years[680].

**DEEMED MEASURE COST**

The incremental capital cost for this measure is $1,000, for a HPWH with an energy factor of 2.0. The full cost, applicable in a retrofit, is $1,575. For a HPWH with an energy factor of 2.35, these costs are $1,134 and $1,703 respectively[681].

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

Loadshape R03 - Residential Electric DHW

**COINCIDENCE FACTOR**

The summer Peak Coincidence Factor is assumed to be 12%[682].

---

[680] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Page 8-52
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf
[681] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf
[682] Calculated from Figure 8 "Combined six-unit summer weekday average electrical demand" in FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters
http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf  as (average kW usage during peak period * hours in

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh = $(((1/EF_{BASE} - 1/EF_{EFFICIENT}) * GPD * 365.25 * γWater * (T_{OUT} - T_{IN}) * 1.0) / 3412) + kWh\_cooling - kWh\_heating$

Where:

| | | |
|---|---|---|
| $EF_{BASE}$ | = Energy Factor (efficiency) of standard electric water heater according to federal standards: | |
| | = 0.93 – (0.00132 * rated volume in gallons)[683] | |
| | = 0.904 for a 50 gallon tank, the most common size for HPWH | |
| $EF_{EFFICIENT}$ | = Energy Factor (efficiency) of Heat Pump water heater | |
| | = Actual | |
| GPD | = Gallons Per Day of hot water use per household | |
| | = 50 [684] | |
| 365.25 | = Days per year | |
| γWater | = Specific weight of water | |
| | = 8.33 pounds per gallon | |
| $T_{OUT}$ | = Tank temperature | |
| | = 125°F | |
| $T_{IN}$ | = Incoming water temperature from well or municiple system | |
| | = 54°F[685] | |

---

peak period) / [(annual kWh savings / FLH) * hours in peak period] = (0.1 kW * 5 hours) / [(2100 kWh (default assumptions) / 2533 hours) * 5 hours] = 0.12

[683] Current Federal Standard EF, since 2004, for a 50-gal electric storage WH, Federal Register Vol. 66, No. 11/1/17/2001, page 4497, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

[684] Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions," http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

[685] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

---

1.0            = Heat Capacity of water (1 Btu/lb*°F)

3412            = Conversion from BTU to kWh

kWh_cooling[686] = Cooling savings from conversion of heat in home to water heat

$$= (([(GPD * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412) - (GPD * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412) / EF_{NEW}] * LF * 27\%) / COP_{COOL}) * LM$$

Where:

LF            = Location Factor

           = 1.0 for HPWH installation in a conditioned space

           = 0.5 for HPWH installation in an unknown location

           = 0.0 for installation in an unconditioned space

27%            = Portion of reduced waste heat that results in cooling savings[687]

$COP_{COOL}$            = COP of central air conditioning

           = Actual, if unknown, assume 3.08 (10.5 SEER / 3.412)

LM            = Latent multiplier to account for latent cooling demand

           = 1.33 [688]:

kWh_heating      = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

For Natural Gas heating, kWh_heating = 0

For electric heating:

$$= ([(GPD * 365.25 * \rho * (T_{OUT} - T_{IN}) * 1.0) / 3412) - (GPD * 365.25 * \rho * (T_{OUT} - T_{IN}) * 1.0) / 3412) / EF_{NEW}] * LF * 49\%) /$$

---

[686] This algorithm calculates the heat removed from the air by subtracting the HPWH electric consumption from the total water heating energy delivered. This is then adjusted to account for location of the HP unit and the coincidence of the waste heat with cooling requirements, the efficiency of the central cooling and latent cooling demands.

[687] REMRate determined percentage (27%) 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).

[688] A sensible heat ratio (SHR) of 0.75 corresponds to a latent multiplier of 4/3 or 1.33. SHR of 0.75 for typical split system from page 10 of "Controlling Indoor Humidity Using Variable-Speed Compressors and Blowers" by M. A. Andrade and C. W. Bullard, 1999: www.ideals.illinois.edu/bitstream/handle/2142/11894/TR151.pdf

$$COP_{HEAT}$$

Where:

| | |
|---|---|
| 49% | = Portion of reduced waste heat that results in increased heating load[689] |
| $COP_{HEAT}$ | = COP of electric heating system |
| | = actual. If not available use[690]: |

| System Type | Age of Equipment | HSPF Estimate | $COP_{HEAT}$ (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

For example, a 2.0 EF heat pump water heater, in a conditioned space in a home with gas space heat and central air conditioning (SEER 10.5) in Belleville:

ΔkWh   = [(1 / 0.904 – 1 / 2.0) * 50 * 365.25* 8.33 * (125 – 54)] / 3412 + 185 - 0

= 2100 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW   = ΔkWh / Hours * CF

Where:

| | |
|---|---|
| Hours | = Full load hours of water heater |
| | = 2533 [691] |
| CF | = Summer Peak Coincidence Factor for measure |
| | = 0.12 **[692]** |

---

[689] REMRate determined percentage (49%) 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).

[690] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

[691] Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.

[692] Calculated from Figure 8 "Combined six-unit summer weekday average electrical demand" in FEMP study; Field

For example, a 2.0 COP heat pump water heater, in a conditioned space in a home with gas space heat and central air conditioning in Belleville:

$$kW = 2100 / 2533 * 0.12$$

$$= 0.099 \text{ kW}$$

NATURAL GAS SAVINGS

$$\Delta Therms = - (((( GPD * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412) - ((( GPD * 365.25 * \gamma Water * (T_{OUT} - T_{IN}) * 1.0) / 3412) / EF_{EFFICIENT})) * LF * 49\% * 0.03412) / (\eta Heat * \% \text{ Natural Gas})$$

Where:

$\Delta Therms$ = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat.[693]

0.03412 = conversion factor (therms per kWh)

$\eta Heat$ = Efficiency of heating system

= Actual.[694] If not available use 70%.[695]

---

Testing of Pre-Production Prototype Residential Heat Pump Water Heaters
http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf as (average kW usage during peak period * hours in peak period) / [(annual kWh savings / FLH) * hours in peak period] = (0.1 kW * 5 hours) / [(2100 kWh / 2533 hours) * 5 hours] = 0.12

[693] This is the additional energy consumption required to replace the heat removed from the home during the heating season by the heat pump water heater. kWh_heating (electric resistance) is that additional heating energy for a home with electric resistance heat (COP 1.0). This formula converts the additional heating kWh for an electric resistance home to the MMBtu required in a Natural Gas heated home, applying the relative efficiencies.

[694] Ideally, the System Efficiency should 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.

[695] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:
http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls ))

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

---

% Natural Gas     = Factor dependent on heating fuel:

| Heating System | %Natural Gas |
|---|---|
| Electric resistance or heat pump | 0% |
| Natural Gas | 100% |
| Unknown heating fuel[696] | 87% |

Other factors as defined above

For example, a 2.0 COP heat pump water heater in conditioned space, in a home with gas space heat (70% system efficiency):

$$\Delta Therms = - (1582.9 * 1 * 0.49 * 0.03412) / 0.7 * 1$$

$$= - 35.1 \text{ therms}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-HPWH-V01-060112**

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[696] 2010 American Community Survey.

## 7.4.4   Low Flow Faucet Aerators

### DESCRIPTION

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture.

This measure was developed to be applicable to the following program types:  TOS, NC, RF, DI.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an energy efficient faucet aerator, for bathrooms rated at 1.5 gallons per minute (GPM) or less, or for kitchens rated at 2.2 GPM or less. Savings are calculated on an average savings per faucet fixture basis.

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or more, or a standard kitchen faucet aerator rated at 2.75 GPM or more.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 9 years[697].

### DEEMED MEASURE COST

The incremental cost for this measure is $8[698] or program actual.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R03 - Residential Electric DHW

### COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.2%[699].

---

[697] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
"http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"
[698] Direct-install price per faucet assumes cost of aerator and install time. (2011, Market research average of $3 and assess and install time of $5 (20min @ $15/hr)
[699] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365 = 3.21%. The number of hours of recovery during peak

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

**NOTE THESE SAVINGS ARE *PER* FAUCET RETROFITTED[700].**

$\Delta$kWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * EPG_electric * ISR

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

| DHW fuel | %ElectricDHW |
|----------|--------------|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 16%[701] |

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet "as-used"

= 1.2[702] or custom based on metering studies[703]

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used"

= 0.94[704] or custom based on metering studies[705]

---

periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

[700] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

[701] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[702] Representative baseline flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7 (see source table at end of characterization). This accounts for all throttling and differences from rated flow rates. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use.

[703] Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

[704] Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7(see source table at end of characterization). This accounts for all throttling and differences from rated flow rates. Assumes all kitchen aerators at 2.2 gpm or less and all bathroom aerators at 1.5 gpm or less. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length

---

L_base = Average baseline length faucet use per capita for all faucets in minutes

= 9.85 min/person/day[706] or custom based on metering studies

L_low = Average retrofit length faucet use per capita for all faucets in minutes

= 9.85 min/person/day[707] or custom based on metering studies

Household = Average  number of people per household

| Household Unit Type | Household |
|---|---|
| Single-Family - Deemed | 2.56[708] |
| Multi-Family - Deemed | 2.1[709] |
| Custom | Actual Occupancy or Number of Bedrooms[710] |

365.25 = Days in a year, on average.

---

of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use. It is possible that programs installing low flow aerators lower than the 2.2 gpm for kitchens and 1.5 gpm for bathrooms will see a lower overall average retrofit flow rate.

[705] Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

[706] This coincides with the middle of the range (6.74 min/person/day to 13.4 min/person/day) from sources 2, 3, 4, and 5 (See Source Table at end of measure section). A recent Midwest evaluation study included a small metering sample with measured faucet use at 4.5 min/person/day for kitchen faucets and 2.6 min/person/day for bathroom faucets. This sample was too small to extrapolate to the population as a whole, but is within the range of total faucet time per the referenced reports and confirms previous findings.

[707] Set equal to L_base. Studies show conflicting results with some studies showing increased time for retrofit homes and some showing decreased time. Engineering judgment leads us to conclude that using the baseline time is a reasonable assumption.

[708] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[709] ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[710] Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.

DF  = Drain Factor

| Faucet Type | Drain Factor[711] |
|---|---|
| Kitchen | 75% |
| Bath | 90% |
| Unknown | 79.5% |

FPH  = Faucets Per Household

| Faucet Type | FPH |
|---|---|
| Kitchen Faucets Per Home (KFPH) | 1 |
| Bathroom Faucets Per Home (BFPH): Single-Family | 2.83[712] |
| Bathroom Faucets Per Home (BFPH): Multi-Family | 1.5[713] |

EPG_electric  = Energy per gallon of water used by faucet supplied by electric water heater

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_electric * 3412)

= (8.33 * 1.0 * (90 – 54.1)) / (0.98 * 3412)

= 0.0894 kWh/gal

8.33  = Specific weight of water (lbs/gallon)

1.0  = Heat Capacity of water (btu/lb-F)

WaterTemp  = Assumed temperature of mixed water

= 90F [714]

SupplyTemp  = Assumed temperature of water entering house

= 54.1F [715]

---

[711] Because faucet usages are at times dictated by volume, only usage of the sort that would go straight down the drain will provide savings. VEIC is unaware of any metering study that has determined this specific factor and so through consensus with the Illinois Technical Advisory Group have deemed these values to be 75% for the kitchen and 90% for the bathroom. If the aerator location is unknown an average of 79.5% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7*0.75)+(0.3*0.9)=0.795.

[712]Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.

[713] Ibid.

[714] Temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm. This is a variable that would benefit from further evaluation.

RE_electric      = Recovery efficiency of electric water heater

= 98% [716]

3412      = Converts Btu to kWh (btu/kWh)

ISR      = In service rate of faucet aerators dependant on install method as listed in table below[717]

| Selection | ISR |
|---|---|
| Direct Install - Deemed | 0.95 |
| Self-Install - Deemed | 0.48 |

For example, a direct installed faucet in a single-family electric DHW home:

$$\Delta kWh = 1.0 * ((1.2 * 9.85 - 0.94 * 9.85) * 2.56 * 365.25 * 0.795 / (1+2.83)) * 0.0894 * 0.95$$

$$= 42.2 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

$\Delta kWh$    = calculated value above

Hours    = Annual electric DHW recovery hours for faucet use

= ((GPM_base * L_base) * Household * 365.25 * DF ) * 0.545[718] / GPH

= 197 for SF; 162 for MF

GPH    = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 27.51

CF    = Coincidence Factor for electric load reduction

---

[715] US DOE Building America Program. Building America Analysis Spreadsheet.  For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
[716] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576
[717] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8
[718] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

$= 0.022$[719].

---

For example, a direct installed faucet in a single family electric DHW home:

$$\Delta kW = 48/197 * 0.022$$

$$= 0.005kW$$

---

**NATURAL GAS SAVINGS**

$\Delta Therms = \%FossilDHW * ((GPM\_base * L\_base - GPM\_low * L\_low) * Household * 365.25 * DF / FPH) * EPG\_gas * ISR$

Where:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

| DHW fuel | %Fossil_DHW |
|----------|-------------|
| Electric | 0% |
| Natural Gas | 100% |
| Unknown | 84%[720] |

EPG_gas = Energy per gallon of Hot water supplied by gas

$= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE\_gas * 100,000)$

= 0.0040 Therm/gal for SF homes

= 0.0045 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 75% For SF homes[721]

---

[719] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

[720] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[721] DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. 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%.

---

= 67% For MF homes[722]

100,000 = Converts Btus to Therms (btu/Therm)

Other variables as defined above.

---

For example, a direct-installed faucet aerator in a fuel DHW single-family home:

ΔTherms = 1.0 * ((1.2 * 9.85 − 0.94 * 9.85) * 2.56 * 365.25 *0.795 / (1+2.83)) * 0.0040 * 0.95

= 1.89 Therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * ISR

Variables as defined above

---

For example, a direct-installed aerator in a single family home

Δgallons = ((1.2 * 9.85 − 0.94 * 9.85) * 2.56 * 365.25 *0.795 / (1+2.83)) * 0.95

= 472 gallons

---

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

---

[722] MF hot water is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average is used for this analysis as a default.

**SOURCES**

| Source ID | Reference |
|---|---|
| 1 | 2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011. |
| 2 | 2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000. |
| 3 | 1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999. |
| 4 | 2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003. |
| 5 | 2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011. |
| 6 | 2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011. |
| 7 | 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. |

**MEASURE CODE: RS-HWE-LFFA-V01-060112**

## 7.4.5   Low Flow Showerheads

### DESCRIPTION

This measure relates to the installation of a low flow showerhead in a single or multi-family household.

This measure was developed to be applicable to the following program types:  TOS, RF, NC, DI.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an energy efficient showerhead rated at 2.0 gallons per minute (GPM) or less. Savings are calculated on a per showerhead fixture basis.

### DEFINITION OF BASELINE EQUIPMENT

For Direct-install programs, the baseline condition is assumed to be a standard showerhead rated at 2.5 GPM or greater.

For retrofit and time-of-sale programs, the baseline condition is assumed to be a representative average of existing showerhead flow rates of participating customers including a range of low flow showerheads, standard-flow showerheads, and high-flow showerheads.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[723].

### DEEMED MEASURE COST

The incremental cost for this measure is $12[724] or program actual.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R03 - Residential Electric DHW

### COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%[725].

---

[723] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.  Evaluations indicate that consumer dissatisfaction may lead to reductions in persistence, particularly in Multi-Family ,
"http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"

[724] Direct-install price per showerhead assumes cost of showerhead (Market research average of $7 and assess and install time of $5 (20min @ $15/hr)

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

Note these savings are per showerhead fixture

ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

| DHW fuel | %ElectricDHW |
|---|---|
| Electric | 100% |
| Natural Gas | 0% |
| Unknown | 16%[726] |

GPM_base = Flow rate of the baseline showerhead

| Program | GPM_base |
|---|---|
| Direct-install | 2.67[727] |
| Retrofit or TOS | 2.35[728] |

---

[725] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period, where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

[726] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[727] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

[728] Representative value from sources 1, 2, 4, 5, 6 and 7 (See Source Table at end of measure section) adjusted slightly upward to account for program participation which is expected to target customers with existing higher flow devices rather than those with existing low flow devices.

---

GPM_low = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaulations deviate from rated flows, see table below:

| Rated Flow |
| --- |
| 2.0 GPM |
| 1.75 GPM |
| 1.5 GPM |
| Custom or Actual[729] |

L_base = Shower length in minutes with baseline showerhead

= 8.20 min[730]

L_low = Shower length in minutes with low-flow showerhead

= 8.20 min[731]

Household = Average number of people per household

| Household Unit Type[732] | Household |
| --- | --- |
| Single-Family - Deemed | 2.56[733] |
| Multi-Family - Deemed | 2.1[734] |
| Custom | Actual Occupancy or Number of Bedrooms[735] |

SPCD = Showers Per Capita Per Day

= 0.75[736]

365.25 = Days per year, on average.

---

[729] Note that actual values may be either a) program-specific minimum flow rate, or b)program-specific evaluation-based value of actual effective flow-rate due to increased duration or temperatures. The latter increases in likelihood as the rated flow drops and may become significant at or below rated flows of 1.5 GPM. The impact can be viewed as the inverse of the throttling described in the footnote for baseline flowrate.

[730] Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)

[731] Set equal to L_base.

[732] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

[733] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[734] ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[735] Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.

[736] Source ID 3

SPH    = Showerheads Per Household so that per-showerhead savings fractions can be determined

| Household Type | SPH |
|---|---|
| Single-Family | 1.79[737] |
| Multi-Family | 1.3[738] |
| Custom | Actual |

EPG_electric  = Energy per gallon of hot water supplied by electric

       = (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3412)

       = (8.33 * 1.0 * (105 – 54.1)) / (0.98 * 3412)

       = 0.127 kWh/gal

8.33     = Specific weight of water (lbs/gallon)

1.0      = Heat Capacity of water (btu/lb-F)

ShowerTemp  = Assumed temperature of water

       = 105F [739]

SupplyTemp  = Assumed temperature of water entering house

       = 54.1F [740]

RE_electric   = Recovery efficiency of electric water heater

       = 98% [741]

3412     = Converts Btu to kWh (btu/kWh)

ISR      = In service rate of showerhead

       = Dependant on program delivery method as listed in table below

---

[737] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[738] Ibid.
[739] Shower temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm
[740] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
[741] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

| Selection | ISR[742] |
|---|---|
| Direct Install - Deemed | 0.98 |
| Self-Install - Deemed | 0.81 |

For example, a direct-installed 1.5 GPM showerhead in a single family home with electric DHW where the number of showers is not known:

$$\Delta kWh = 1.0 * ((2.67 * 8.2 - 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.127 * 0.98$$

$$= 468 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

$\Delta kWh$ = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

= ((GPM_base * L_base) * Household * SPCD * 365.25 ) * 0.773[743] / GPH

= 431 for SF Direct Install; 354 for MF Direct Install

= 380 for SF Retrofit and TOS; 311 for MF Retrofit and TOS

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.0278[744]

---

[742] Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.

[743] 77.3% is the proportion of hot 120F water mixed with 54.1F supply water to give 105F shower water.

[744] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during

> For example, a direct installed 1.5 GPM showerhead in a single family home with electric DHW where the number of showers is not known:
>
> $$\Delta kW = 468/431 * 0.0278$$
>
> $$= 0.030 \text{ kW}$$

**NATURAL GAS SAVINGS**

$\Delta$Therms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR

Where:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

| DHW fuel | %Fossil_DHW |
|---|---|
| Electric | 0% |
| Natural Gas | 100% |
| Unknown | 84%[745] |

EPG_gas = Energy per gallon of Hot water supplied by gas

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_gas * 100,000)

= 0.0054 Therm/gal for SF homes

= 0.0063 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[746]

= 67% For MF homes[747]

---

the peak period is 7.23/260 = 0.0278

[745] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[746] DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. 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 78%.

[747] MF hot water is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average is used for this analysis as a default.

100,000 = Converts Btus to Therms (btu/Therm)

Other variables as defined above.

---

For example, a direct installed 1.5 GPM showerhead in a gas fired DHW single family home where the number of showers is not known:

ΔTherms = 1.0 * ((2.67 * 8.2 – 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.0054 * 0.98

= 19.9 therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * ISR

Variables as defined above

---

For example, a direct installed 1.5 GPM showerhead where the number of showers is not known:

Δgallons = ((2.67 * 8.2 – 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.98

= 3438 gallons

---

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**SOURCES**

| Source ID | Reference |
|---:|---|
| 1 | 2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011. |
| 2 | 2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000. |
| 3 | 1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999. |
| 4 | 2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003. |
| 5 | 2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011. |
| 6 | 2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011. |
| 7 | 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. |

**MEASURE CODE: RS-HWE-LFSH-V01-060112**

## 7.4.6   Water Heater Temperature Setback

### DESCRIPTION

The thermostat setting of a hot water tank is lowered to 120 degrees.   The savings are from the Connecticut TRM which considers that for some draws, the hot water flow will be increased to make up for the lower temperature, and that additional dishwasher's supplemental heating will be required.

This measure was developed to be applicable to the following program types:  NC, RF, DI.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

High efficiency is a hot water tank with the thermostat set at 120 degrees.

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a hot water tank with a thermostat setting that is higher than 120 degrees, typically systems with settings of 130 degrees or higher, this analysis assumes a 15 degree setback.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 2 years.

### DEEMED MEASURE COST

The incremental cost of a setback is assumed to be $5 for contractor time.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R03 - Residential Electric DHW

### COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 1.

---

**Algorithm**

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### CALCULATION OF SAVINGS

### ELECTRIC ENERGY SAVINGS

For homes with electric DHW tanks:

ΔkWh = 86.4 kWh [748]

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW **=** ΔkWh / Hours * CF

Where:

Hours = 8766

CF = Summer Peak Coincidence Factor for measure

= 1

ΔkW = 86.4 / 8766 * 1

= 0.00986 kW

**NATURAL GAS SAVINGS**

For homes with gas water heaters:

ΔTherms = 6.4 therms [749]

ΔkWh = -34.2 kWh [750]

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-TMPS-V01-060112**

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[748] All savings estimates are based on UL and CLP Program Savings Documentation, 2010. This is the net savings after taking into account increased use of dishwasher's supplemental heating.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/CT-UI_CLP_2010_PSD.pdf

[749] All savings estimates are based on UL and CLP Program Savings Documentation, 2010. The Δtherms are the gross savings for a gas heater. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/CT-UI_CLP_2010_PSD.pdf

[750] The ΔkWh accounts for the increased use of dishwasher's supplemental heating.

## 7.4.7   Water Heater Wrap

### 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.[751]

This measure was developed to be applicable to the following program types: RF, DI.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The measure is a properly installed, R-8 or greater 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 LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 5 years[752].

### 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

### LOADSHAPE

Loadshape R03 - Residential Electric DHW

### COINCIDENCE FACTOR

This measure assumes a flat loadshape and as such the coincidence factor is 1.

---

**Algorithm**

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[751] Visually determine whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)

[752] This estimate assumes the tank wrap is installed on an existing unit with 5 years remaining life.

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

For electric DHW systems:

$$\Delta kWh = ((U_{base}A_{base} - U_{insul}A_{insul}) * \Delta T * Hours) / (3.412 * \eta DHW)$$

Where:

| | |
|---|---|
| $U_{base}$ | = Overall heat transfer coefficient prior to adding tank wrap (Btu/Hr-F-ft2). |
| $U_{insul}$ | = Overall heat transfer coefficient after addition of tank wrap (Btu/Hr-F-ft2). |
| $A_{base}$ | = Surface area of storage tank prior to adding tank wrap (square feet)[753] |
| $A_{insul}$ | = Surface area of storage tank after addition of tank wrap (square feet)[754] |
| $\Delta T$ | = Average temperature difference between tank water and outside air temperature (°F) |
| | = 60°F [755] |
| Hours | = Number of hours in a year (since savings are assumed to be constant over year). |
| | = 8766 |
| 3412 | = Conversion from BTU to kWh |
| $\eta DHW$ | = Recovery efficiency of electric hot water heater |
| | = 0.98 [756] |

---

[753] Area includes tank sides and top to account for typical wrap coverage.
[754] Ibid.
[755] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.
[756] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

The following table has default savings for various tank capacity and pre and post R-VALUES.

| Capacity (gal) | Rbase | Rinsul | Abase (ft2)[757] | Ainsul (ft2)[758] | ΔkWh | ΔkW |
|---|---|---|---|---|---|---|
| 30 | 8 | 16 | 19.16 | 20.94 | 171 | 0.0195 |
| 30 | 10 | 18 | 19.16 | 20.94 | 118 | 0.0135 |
| 30 | 12 | 20 | 19.16 | 20.94 | 86 | 0.0099 |
| 30 | 8 | 18 | 19.16 | 20.94 | 194 | 0.0221 |
| 30 | 10 | 20 | 19.16 | 20.94 | 137 | 0.0156 |
| 30 | 12 | 22 | 19.16 | 20.94 | 101 | 0.0116 |
| 40 | 8 | 16 | 23.18 | 25.31 | 207 | 0.0236 |
| 40 | 10 | 18 | 23.18 | 25.31 | 143 | 0.0164 |
| 40 | 12 | 20 | 23.18 | 25.31 | 105 | 0.0120 |
| 40 | 8 | 18 | 23.18 | 25.31 | 234 | 0.0268 |
| 40 | 10 | 20 | 23.18 | 25.31 | 165 | 0.0189 |
| 40 | 12 | 22 | 23.18 | 25.31 | 123 | 0.0140 |
| 50 | 8 | 16 | 24.99 | 27.06 | 225 | 0.0257 |
| 50 | 10 | 18 | 24.99 | 27.06 | 157 | 0.0179 |
| 50 | 12 | 20 | 24.99 | 27.06 | 115 | 0.0131 |
| 50 | 8 | 18 | 24.99 | 27.06 | 255 | 0.0291 |
| 50 | 10 | 20 | 24.99 | 27.06 | 180 | 0.0206 |
| 50 | 12 | 22 | 24.99 | 27.06 | 134 | 0.0153 |
| 80 | 8 | 16 | 31.84 | 34.14 | 290 | 0.0331 |
| 80 | 10 | 18 | 31.84 | 34.14 | 202 | 0.0231 |
| 80 | 12 | 20 | 31.84 | 34.14 | 149 | 0.0170 |
| 80 | 8 | 18 | 31.84 | 34.14 | 328 | 0.0374 |
| 80 | 10 | 20 | 31.84 | 34.14 | 232 | 0.0265 |
| 80 | 12 | 22 | 31.84 | 34.14 | 173 | 0.0198 |

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / 8766 * CF$$

Where:

ΔkWh = kWh savings from tank wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

CF = Summer Coincidence Factor for this measure

= 1.0

The table above has default kW savings for various tank capacity and pre and post R-values.

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[757] Assumptions from PA TRM. Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation. Area includes tank sides and top to account for typical wrap coverage.

[758] Assumptions from PA TRM. $A_{insul}$ was calculated by assuming that the water heater wrap is a 2" thick fiberglass material.

**NATURAL GAS SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-HWE-WRAP-V01-060112**

## 7.5    Lighting End Use

### 7.5.1    ENERGY STAR Compact Fluorescent Lamp (CFL)

**OFFICIAL MEASURE CODE**

**DESCRIPTION**

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of an incandescent screw-in bulb.

This characterization assumes that the CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program), evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

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. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W 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 and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure.  For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

This measure was developed to be applicable to the following program types:  TOS, NC, DI.
If applied to other program types, the measure savings should be verified.

**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**

The baseline equipment is assumed to be a standard incandescent light bulb, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb becomes 53W in June 2012 and 60W and 40W bulbs become 43W and 29W respectively in June 2014. Annual

savings are reduced to account for this baseline shift within the life of a measure and the measure life is reduced to account for the baseline replacements becoming equivalent to a current day CFL by June 2020.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life (number of years that savings should be claimed) for bulbs installed June 2012 – May 2013 is assumed to be 5.2 years[759]. For bulbs installed June 2015 – May 2016, this would be reduced to 5 years and then for every subsequent year should be reduced by one year[760].

### DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost is $1.90, from June 2012 – May 2013, $1.80 from June 2013 – May 2014 and $1.50 from June 2014 – May 2015[761].

For the Direct Install measure, the full cost of $2.50 per bulb should be used.

### DEEMED O&M COST ADJUSTMENTS

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below[762]:

| Lumen Range | NPV of baseline replacement costs | | |
|---|---|---|---|
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $5.41 | $5.41 | $5.41 |
| 1050-1489 | $5.41 | $5.41 | $5.41 |
| 750-1049 | $4.48 | $5.41 | $5.41 |
| 310-749 | $4.48 | $5.41 | $5.41 |

---

[759] Jump et al 2008: "Welcome to the Dark Side: The Effect of Switching on CFL Measure Life" indicates that the "observed life" of  CFLs with an average rated life of 8000 hours (8000 hours is the average rated life of ENERGY STAR bulbs (http://www.energystar.gov/index.cfm?c=cfls.pr_crit_cfls) is 5.2 years.

[760] Since the replacement baseline bulb from 2020 on will be equivalent to a CFL, no additional savings should be claimed from that point. Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

[761] Based on Northeast Regional Residential Lighting Strategy (RLS) report, prepared by EFG, D&R International, Ecova and Optimal Energy, applying sales weighting and phase-in of EISA regulations. Assumption is $2.50 for CFL over three years and $0.6 for baseline in 2012, $0.70 in 2013 and $1.00 in 2014 as more expensive EISA qualified bulbs become baseline.

[762] See 'RES Standard CFL O&M calc.xls' for more details.

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| Lumen Range | Levelized annual replacement cost savings | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $1.22 | $1.22 | $1.22 |
| 1050-1489 | $1.22 | $1.22 | $1.22 |
| 750-1049 | $1.01 | $1.22 | $1.22 |
| 310-749 | $1.01 | $1.22 | $1.22 |

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

| Lumen Range | NPV of baseline replacement costs | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $13.09 | $13.09 | $13.09 |
| 1050-1489 | $8.24 | $13.09 | $13.09 |
| 750-1049 | $4.36 | $8.24 | $13.09 |
| 310-749 | $4.36 | $8.24 | $13.09 |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| Lumen Range | Levelized annual replacement cost savings | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $8.34 | $8.34 | $8.34 |
| 1050-1489 | $5.25 | $8.34 | $8.34 |
| 750-1049 | $2.78 | $5.25 | $8.34 |
| 310-749 | $2.78 | $5.25 | $8.34 |

**LOADSHAPE**

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Loadshape C06 - Commercial Indoor Lighting[763]

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[763] For Multi Family common area lighting.

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%[764] for Residential and in-unit Multi Family bulbs and 75%[765] for Multi Family common area bulbs.

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## Algorithm

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh        = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase        = Based on lumens of CFL bulb and program year purchased / installed:

| Minimum Lumens | Maximum Lumens | Incandescent Equivalent Pre-EISA 2007 (Watts$_{Base}$) | Incandescent Equivalent Post-EISA 2007 (Watts$_{Base}$) | Effective date from which Post – EISA 2007 assumption should be used |
|---|---|---|---|---|
| 1490 | 2600 | 100 | 72 | June 2012 |
| 1050 | 1489 | 75 | 53 | June 2013 |
| 750 | 1049 | 60 | 43 | June 2014 |
| 310 | 749 | 40 | 29 | June 2014 |

WattsEE        = Actual wattage of CFL purchased / installed

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[764] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
 "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf
[765] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

ISR = In Service Rate, the percentage of units rebated that are actually in service.

| Program | Weighted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|---|
| Retail (Time of Sale) | 69.5%[766] | 15.4% | 13.1% | 98.0%[767] |
| Direct Install | 96.9%[768] | | | |

Hours = Average hours of use per year

| Installation Location | Hours |
|---|---|
| Residential and in-unit Multi Family | 938 [769] |
| Multi Family Common Areas | 5,950 [770] |
| Exterior | 1,825 [771] |
| Unknown | 1,000 [772] |

---

[766] 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption.

[767] The 98% Lifetime ISR assumption is based upon review of two evaluations:

'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[768] Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010. http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf.

[769] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

[770] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[771] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

[772] Assumes 7% exterior lighting, based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

| Bulb Location | WHFe |
|---|---|
| Interior single family or unknown location | 1.06 [773] |
| Multi family in unit | 1.04 [774] |
| Multi family common area | 1.04 [775] |
| Exterior or uncooled location | 1.0 |

**MID LIFE BASELINE ADJUSTMENT**

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, 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 adjustment factors are provided below.

| Lumen Range | Pre EISA WattsBase | Post EISA WattsBase | CFL Equivalent | Delta Watts Before EISA | Delta Watts After EISA | Mid Life Adjustment | Adjustment made from date |
|---|---|---|---|---|---|---|---|
| 1490-2600 | 100 | 72 | 25 | 75 | 47 | 63% | N/A (2012 is already post EISA) |
| 1050-1489 | 75 | 53 | 20 | 55 | 33 | 60% | June, 2013 |
| 750-1049 | 60 | 43 | 14 | 46 | 29 | 63% | June, 2014 |
| 310-749 | 40 | 29 | 11 | 29 | 18 | 62% | June, 2014 |

---

[773] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)).  Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9  Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20 Region.xls )

[774] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1  Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%2 0Unit%20Type.xls

[775] Ibid.

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For example, a 20W standard CFL, 1200 lumen is purchased in 2012 and installed in a single family interior location:

First Year Installs:

$\Delta kWH_{1st\ year}$ = ((75 - 20) / 1000) * 0.695 * 938 * 1.06

= 38 kWh

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (38 * 0.6 =) 22.8kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

Second Year Installs:

$\Delta kWH_{2nd\ year}$ = ((53 - 20) / 1000) * 0.154 * 938 * 1.06

= 5.0 kWh

Note since this is now being installed in 2013 the baseline wattage is adjusted to 53W due to the EISA legislation.

Third Year Installs:

$\Delta kWH_{3rd\ year}$ = ((53- 20) / 1000) * 0.131 * 938 * 1.06

= 4.3 kWh

**HEATING PENALTY**

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$\Delta kWh$[776] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / $\eta Heat$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[777] for interior or unknown location

= 0% for exterior or unheated location

---

[776] Negative value because this is an increase in heating consumption due to the efficient lighting.
[777] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[778]:

| System Type | Age of Equipment | HSPF Estimate | ηHeat (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

---

For example, a 20W standard CFL, 1200 lumen is purchased in 2012 and installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((75 - 20) / 1000) * 0.695 * 938 * 0.49) / 2.0

= - 8.8 kWh

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

---

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW$ = ((WattsBase - WattsEE) / 1 000) * ISR * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

| Bulb Location | WHFd |
|---|---|
| Interior single family or unknown location | 1.11[779] |
| Multi family in unit | 1.07[780] |
| Multi family common area | 1.07 [781] |
| Exterior or uncooled location | 1.0 |

---

[778] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

[779] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[780] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

[781] Ibid

CF                     = Summer Peak Coincidence Factor for measure.

| Bulb Location | CF |
|---|---|
| Interior single family or unknown location | 9.5% [782] |
| Multi family in unit | 9.5% [783] |
| Multi family common area | 75% [784] |

Other factors as defined above

For example, a 20W standard CFL, 1200 lumen is purchased and installed in a single family interior location in 2012:

$\Delta$kW     = ((75 - 20) / 1000) * 0.695 * 1.11 * 0.095

          = 0.004 kW

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

**NATURAL GAS SAVINGS**

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

$\Delta$Therms[785]  = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / $\eta$Heat

Where:

HF                     = Heating Factor or percentage of light savings that must be heated

                       = 49%[786] for interior or unknown location

                       = 0% for exterior or unheated location

0.03412            =Converts kWh to Therms

---

[782] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
 "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf
[783] Ibid.
[784] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.
[785] Negative value because this is an increase in heating consumption due to the efficient lighting.
[786] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

ηHeat        = Efficiency of heating system

=70%[787]

---

For example, a 20W standard CFL, 1200 lumen is purchased and installed in a home in 2012:

ΔTherms        = - (((75 - 20) / 1000) * 0.695 * 938 * 0.49 * 0.03412) / 0.7

= - 0.86 Therms

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

---

**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 Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see RES Standard CFL O&M calc.xls). The key assumptions used in this calculation are documented below:

|  | Standard Incandescent | Efficient Incandescent |
|---|---|---|
| Replacement Cost | $0.50 | $1.50 |
| Component Rated Life (hrs) | 1000 | 1000[788] |

---

[787] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:
http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) =  0.70
[788] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

| Lumen Range | NPV of baseline replacement costs | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $5.41 | $5.41 | $5.41 |
| 1050-1489 | $5.41 | $5.41 | $5.41 |
| 750-1049 | $4.48 | $5.41 | $5.41 |
| 310-749 | $4.48 | $5.41 | $5.41 |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| Lumen Range | Levelized annual replacement cost savings | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $1.22 | $1.22 | $1.22 |
| 1050-1489 | $1.22 | $1.22 | $1.22 |
| 750-1049 | $1.01 | $1.22 | $1.22 |
| 310-749 | $1.01 | $1.22 | $1.22 |

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

| Lumen Range | NPV of baseline replacement costs | | |
| --- | --- | --- | --- |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $13.09 | $13.09 | $13.09 |
| 1050-1489 | $8.24 | $13.09 | $13.09 |
| 750-1049 | $4.36 | $8.24 | $13.09 |
| 310-749 | $4.36 | $8.24 | $13.09 |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| Lumen Range | Levelized annual replacement cost savings | | |
|---|---|---|---|
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 |
| 1490-2600 | $8.34 | $8.34 | $8.34 |
| 1050-1489 | $5.25 | $8.34 | $8.34 |
| 750-1049 | $2.78 | $5.25 | $8.34 |
| 310-749 | $2.78 | $5.25 | $8.34 |

**MEASURE CODE: RS-LTG-ESCF-V01-060112**

## 7.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

### DESCRIPTION

An ENERGY STAR qualified specialty compact fluorescent bulb is installed in place of an incandescent specialty bulb. Specialty CFL bulbs are defined as lamps for general illumination that use fluorescent light emitting technology and an integrated electronic ballast with or without a standard Edison screw-base. Specialty bulbs defined in this characterization are exempt of the EISA 2007 standard and may include the following bulb types: three-way, plant light, daylight bulb, bug light, post light, globes G40, candelabra base, vibration service bulb, decorative candle with medium or intermediate base, shatter resistant, reflector (the exemption on reflector bulbs is expected to expire in 2014 for the following wattage and bulb type: 45 W (R20 and BR 19); 50W (R30, ER 30, BR 40, and ER 40); 65W (BR30, BR40, and ER 404)).

This characterization assumes that the specialty CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) evaluation data could be used to determine an appropriate residential vs. commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations, to be appropriately conservative in savings assumptions.

This measure was developed to be applicable to the following program types: TOS, NC, DI.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

Energy Star qualified specialty CFL bulb as defined above that is exempt from EISA 2007. Due to A-line and dimmable bulbs not being exempt from EISA, this measure characterization will be used most often for flood light/reflector/spotlight (until exemption expires), and globes, which make up the majority of specialty program bulbs.[789]

### DEFINITION OF BASELINE EQUIPMENT

The baseline is a specialty incandescent light bulb.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6.8 year[790].

### DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5[791].

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[789] Lighting and Appliance Evaluation – PY 2, Ameren Illinois, Prepared by The Cadmus Group Inc. / Energy Services, December 2010.

[790] The assumed measure life for the specialty bulb measure characterization was reported in "Residential Lighting Measure Life Study", Nexus Market Research, June 4, 2008 (measure life for markdown bulbs). Measure life estimate does not distinguish between equipment life and measure persistence. Measure life includes products that were installed and operated until failure (i.e., equipment life) as well as those that were retired early and permanently removed from service for any reason, be it early failure, breakage, or the respondent not liking the product (i.e., measure persistence).

For the Direct Install measure, the full cost of $8.50 should be used.

### DEEMED O&M COST ADJUSTMENTS

Life of the baseline bulb is assumed to be 1.07 year[792]; baseline replacement cost is assumed to be $3.5[793].

### LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Loadshape C06 - Commercial Indoor Lighting[794]

### COINCIDENCE FACTOR

Unlike standard CFLs that could be installed in any room, certain types of specialty CFLs are more likely to be found in specific rooms, which affects the coincident peak factor. Coincidence factors by bulb types are presented below[795]

| Bulb Type | Peak CF |
|---|---|
| Three-way | 0.081 |
| A-bulb (covered) | *** |
| Dimmable | *** |
| Interior reflector (incl. dimmable) | 0.095 |
| Exterior reflector | 0.184 |
| Candelabra base and candle medium and intermediate base | 0.122 |
| Bug light | 0.184 |
| Post light (>100W) | 0.184 |
| Daylight | 0.095 |
| Plant light | 0.095 |
| Globe | 0.116 |
| Vibration or shatterproof | 0.095 |
| Specialty - Generic | 0.095 |

***N/A, not exempt from EISA, use the standard bulb measure characterization

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[791] NEEP Residential Lighting Survey, 2011

[792] Assuming 1000 hour rated life for incandescent bulb: 1000/938 = 1.07

[793] NEEP Residential Lighting Survey, 2011

[794] For Multi Family common area lighting.

[795] Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed. http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh　　= ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase　　= Actual wattage equivalent of incandescent specialty bulb, use the table below to obtain the incandescent bulb equivalent wattage[796]; use 60W if unknown[797]

| Incandescent Bulbs (watts) | Minimum Light Output (lumens) | Common ENERGY STAR Qualified Bulbs (Watts) |
|---|---|---|
| 25 | 250 | 4 to 9 |
| 40 | 450 | 9 to 13 |
| 60 | 800 | 13 to 15 |
| 75 | 1,110 | 18 to 25 |
| 100 | 1,600 | 23 to 30 |
| 125 | 2,000 | 22 to 40 |
| 150 | 2,600 | 40 to 45 |

WattsEE　　= Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown[798]

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[796] Based on ENERGY STAR equivalence table; http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_lumens

[797] A 2006-2008 California Upstream Lighting Evaluation found an average incandescent wattage of 61.7 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program. Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009)

[798] An evaluation (Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: Residential Energy Star ® Lighting http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_Res_Lighting_PY2_Evaluation_Report_2010-12-21_Final.12113928.pdf ) reported 13-17W as the most common specialty CFL wattage (69% of program bulbs). 2009 California data also reported an average CFL wattage of 15.5 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program, Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009).

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ISR = In Service Rate, the percentage of units rebated that are actually in service.

| Program | Weigted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|---|
| Retail (Time of Sale) | 79.5%[799] | 10.0% | 8.5% | 98.0%[800] |
| Direct Install | 96.9%[801] | | | |

Hours = Average hours of use per year, varies by bulb type as presented below:[802]

| Bulb Type | Annual hours of use (HOU) |
|---|---|
| Three-way | 897 |
| A-bulb (covered) | *** |
| Dimmable | *** |
| Interior reflector (incl. dimmable) | 938 |
| Exterior reflector | 1825 |
| Candelabra base and candle medium and intermediate base | 1328 |
| Bug light | 1825 |
| Post light (>100W) | 1825 |
| Daylight | 938 |
| Plant light | 938 |
| Globe | 1240 |
| Vibration or shatterproof | 938 |
| Specialty - Generic | 938 |

***N/A, not exempt from EISA, use the standard bulb measure characterization

[799] 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[800] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:

'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[801] Consistent with assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type). Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010. http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf.

[802] Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Annual hours of use by location in the home from Docket No. 10-0520, ICC Staff Exhibit 1.4, RE: Lighting Logger Study Results – Version 2, Navigant, May 27, 2011. http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

| Bulb Location | WHFe |
|---|---|
| Interior single family or unknown location | 1.06 [803] |
| Multi family in unit | 1.04 [804] |
| Exterior or uncooled location | 1.0 |

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb in single family interior location:

First Year Installs:

$\Delta kWH_{1st\ year}$ = ((60 - 15) / 1000) * 0.795 * 938 * 1.06

= 35.6 kWh

Second Year Installs:

$\Delta kWH_{2nd\ year}$ = ((60 - 15) / 1000) * 0.1 * 938 * 1.06

= 4.5 kWh

Third Year Installs:

$\Delta kWH_{3rd\ year}$ = ((60 - 15) / 1000) * 0.085 * 938 * 1.06

= 3.8 kWh

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[803] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls )

[804] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls

**HEATING PENALTY**

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta kWh^{805} = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / \eta Heat$$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[806] for interior or unknown location

= 0% for exterior location

$\eta$Heat = Efficiency in COP of Heating equipment

= actual. If not available use[807]:

| System Type | Age of Equipment | HSPF Estimate | ηHeat (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb installed in home with 2.0 COP Heat Pump:

$$\Delta kWh_{1st\ year} = - (((60 - 15) / 1000) * 0.795 * 938 * 0.49) / 2.0$$

$$= - 8.2\ kWh$$

Second and third year savings should be calculated using the appropriate ISR.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = ((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF$$

Where:

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[805] Negative value because this is an increase in heating consumption due to the efficient lighting.

[806] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[807] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting. The cooling savings are only added to the summer peak savings.

| Bulb Location | WHFd |
|---|---|
| Interior single family or unknown location | 1.11[808] |
| Multi family in unit | 1.07[809] |
| Exterior or uncooled location | 1.0 |

CF = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below[810]

| Bulb Type | Peak CF |
|---|---|
| Three-way | 0.081 |
| A-bulb (covered) | *** |
| Dimmable | *** |
| Interior reflector (incl. dimmable) | 0.095 |
| Exterior reflector | 0.184 |
| Candelabra base and candle medium and intermediate base | 0.122 |
| Bug light | 0.184 |
| Post light (>100W) | 0.184 |
| Daylight | 0.095 |
| Plant light | 0.095 |
| Globe | 0.116 |
| Vibration or shatterproof | 0.095 |
| Specialty - Generic | 0.095 |

***N/A, not exempt from EISA, use the standard bulb measure characterization

Other factors as defined above

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For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$\Delta kW_{1st\ year}$ = ((60 - 15) / 1000) * 0.795 * 1.11 * 0.095

= 0.004 kW

Second and third year savings should be calculated using the appropriate ISR.

---

[808] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[809] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

[810] Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed.

**NATURAL GAS SAVINGS**

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

$\Delta$Therms[811] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / $\eta$Heat

Where:

| | |
|---|---|
| HF | = Heating Factor or percentage of light savings that must be heated |
| | = 49%[812] for interior or unknown location |
| | = 0% for exterior location |
| 0.03412 | =Converts kWh to Therms |
| $\eta$Heat | = Efficiency of heating system |
| | =70%[813] |

---

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$\Delta$Therms = - (((60 - 15) / 1000) * 0.795 * 938 * 0.49 * 0.03412) / 0.7

= - 0.80 Therms

Second and third year savings should be calculated using the appropriate ISR.

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[811] Negative value because this is an increase in heating consumption due to the efficient lighting.

[812] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[813] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.)

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-LTG-ESCC-V01-060112**

## 7.5.3  ENERGY STAR Torchiere

### 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.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### 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 LIFETIME OF EFFICIENT EQUIPMENT

The lifetime of the measure is assumed to be 8 years[814].

### DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $5[815].

### DEEMED O&M COST ADJUSTMENTS

Life of the baseline bulb is assumed to be 1.83 years[816] for residential and multifamily in unit and 0.34 years[817] for multifamily common area. Baseline bulb cost replacement is assumed to be $6[818].

### LOADSHAPE

  Loadshape R06 - Residential Indoor Lighting
  Loadshape R07 - Residential Outdoor Lighting
  Loadshape C06 - Commercial Indoor Lighting[819]

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[814] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
[815] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
[816] Based on assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.
[817] 2000/5950 = 0.34 years
[818] Derived from Efficiency Vermont TRM.
[819] For Multi Family common area lighting.

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is 9.5%[820] for Residential and in-unit Multi Family bulbs and 75%[821] for Multi Family common area bulbs.

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((\Delta Watts) / 1000) * ISR * HOURS * WHFe$$

Where:

ΔWatts = Average delta watts per purchased ENERGY STAR torchiere

= 115.8 [822]

ISR = In Service Rate or percentage of units rebated that get installed.

= 0.86 [823]

HOURS = Average hours of use per year

| Installation Location | Hours |
|---|---|
| Residential and in-unit Multi Family | 1095 (3.0 hrs per day)[824] |
| Multi Family Common Areas | 5950[825] |

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[820] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
 "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[821] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

[822] 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)

[823] 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 in year one. http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtreportfinal100104.pdf

[824] 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)

[825] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

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WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.

| Bulb Location | WHFe |
|---|---|
| Interior single family or unknown location | 1.06 [826] |
| Multi family in unit | 1.04 [827] |
| Multi family common area | 1.04 [828] |
| Exterior or uncooled location | 1.0 |

For single family buildings:

$$\Delta kWh = (115.8 /1000) * 0.86 * 1095 * 1.06$$

$$= 116 \text{ kWh}$$

For multi family in unit:

$$\Delta kWh = (115.8 /1000) * 0.86 * 1095 * 1.04$$

$$= 113 \text{ kWh}$$

For multi family common area:

$$\Delta kWh = (115.8 /1000) * 0.86 * 5950 * 1.04$$

$$= 616 \text{ kWh}$$

**HEATING PENALTY**

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

---

[826] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)).  Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9  Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20 Region.xls )

[827] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1  Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%2 0Unit%20Type.xls

[828] Ibid.

$$\Delta kWh^{829} = - ((\Delta Watts) /1000) * ISR * HOURS * HF) / \eta Heat$$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[830] for interior or unknown location

$\eta$Heat = Efficiency in COP of Heating equipment

= Actual. If not available use defaults provided below[831]:

| System Type | Age of Equipment | HSPF Estimate | ηHeat (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

For example, an ES torchiere installed in a house with a newer heat pump:

$$\Delta kWh = - ((115.8) / 1000) * 0.86 * 1095 * 0.49) / 2.26$$

$$= - 23.6 \ kWh$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

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

Where:

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[829] Negative value because this is an increase in heating consumption due to the efficient lighting.

[830] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[831] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

        WHFd         = Waste Heat Factor for Demand to account for cooling savings from efficient lighting

| Bulb Location | WHFd |
|---|---|
| Interior single family or unknown location | 1.11[832] |
| Multi family in unit | 1.07[833] |
| Multi family common area | 1.07 [834] |
| Exterior or uncooled location | 1.0 |

        CF         = Summer Peak Coincidence Factor for measure

| Bulb Location | CF |
|---|---|
| Interior single family or unknown location | 9.5% [835] |
| Multi family in unit | 9.5% [836] |
| Multi family common area | 75% [837] |

For single family buildings:

        ΔkW         = (115.8 / 1000) * 0.86 * 1.11 * 0.095

                       = 0.011kW

For multi family in unit:

        ΔkW         = (115.8 / 1000) * 0.86 * 1.07 * 0.095

                       = 0.010 kW

For multi family common area:

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[832] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[833] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1  Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

[834] Ibid

[835] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
 "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[836] Ibid.

[837] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

$$\Delta kW = (115.8 / 1000) * 0.86 * 1.07 * 0.75$$

$$= 0.080 \text{ kW}$$

**NATURAL GAS SAVINGS**

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$$\Delta Therms_{WH} = - (((\Delta Watts) / 1000) * ISR * HOURS * 0.03412 * HF) / \eta Heat$$

Where:

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

0.03412 = conversion from kWh to therms

HF = Heating Factor or percentage of light savings that must be heated

= 49% [838]

$\eta Heat$ = average heating system efficiency

= 70% [839]

$$\Delta Therms_{WH} = - ((115.8 / 1000) * 0.86 * 1095 * 0.03412 * 0.49) / 0.70$$

$$= - 2.60 \text{ therms}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[838] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[839] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: (0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

**DEEMED O&M COST ADJUSTMENT CALCULATION**

Life of the baseline bulb is assumed to be 1.83 years[840] for residential and multifamily in unit and 0.34 years[841] for multifamily common area. Baseline bulb cost replacement is assumed to be $6.**[842]**

**MEASURE CODE: RS-LTG-ESTO-V01-060112**

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[840] Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.
[841] 2000/5950 = 0.34 years
[842] Derived from Efficiency Vermont TRM.

## 7.5.4   Exterior Hardwired Compact Fluorescent Lamp (CFL) Fixture

DESCRIPTION

An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is installed in an exterior residential setting. This measure could relate to either a fixture replacement or new installation (i.e. time of sale).

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. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W 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 and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure.  For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is an ENERGY STAR lighting exterior fixture for pin-based compact fluorescent lamps.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a standard incandescent exterior fixture.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected life of an interior fixture is 20 years[843]. However due to the backstop provision in the Energy Independence and Security Act of 2007 that requires by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, the baseline replacement would become a CFL in that year.  The expected measure life

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[843] 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) gives 20 years for an interior fluorescent fixture.

for CFL fixtures installed June 2012 – May 2013 is therefore assumed to be 8 years. For bulbs installed June 2013 – May 2014, this would be reduced to 7 years and should be reduced each year[844].

**DEEMED MEASURE COST**

The incremental cost for an interior fixture is assumed to be $17[845].

**DEEMED O&M COST ADJUSTMENTS**

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below[846]:

| | NPV of replacement costs per bulb | | | |
| --- | --- | --- | --- | --- |
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
| 1490-2600 | $18.34 | $16.28 | $14.12 | |
| 1050-1489 | $17.36 | $16.28 | $14.12 | $1.90 |
| 750-1049 | $15.50 | $15.30 | $14.12 | |
| 310-749 | $15.50 | $15.30 | $14.12 | |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement costs per bulb | | | |
| --- | --- | --- | --- | --- |
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
| 1490-2600 | $2.86 | $2.54 | $2.20 | |
| 1050-1489 | $2.71 | $2.54 | $2.20 | $0.30 |
| 750-1049 | $2.42 | $2.39 | $2.20 | |
| 310-749 | $2.42 | $2.39 | $2.20 | |

**LOADSHAPE**

Loadshape R07 - Residential Outdoor Lighting

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[844] Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.
[845] ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for exterior fixture (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/LightingCalculator.xlsx?b299-55ae&b299-55ae)
[846] See 'RES CFL Fixture O&M calc.xls' for more details.

**COINCIDENCE FACTOR**

The summer peak coincidence factor is assumed to be 0.4%[847].

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$\Delta kWh$ =((WattsBase - WattsEE) / 1000) * ISR * Hours

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

| Minimum Lumens | Maximum Lumens | Incandescent Equivalent Pre-EISA 2007 (Watts$_{Base}$) | Incandescent Equivalent Post-EISA 2007 (Watts$_{Base}$) | Effective date from which Post – EISA 2007 assumption should be used |
|---|---|---|---|---|
| 1490 | 2600 | 100 | 72 | June 2012 |
| 1050 | 1489 | 75 | 53 | June 2013 |
| 750 | 1049 | 60 | 43 | June 2014 |
| 310 | 749 | 40 | 29 | June 2014 |

WattsEE = Actual wattage of CFL purchased

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[847] Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.

ISR = In Service Rate or the percentage of units rebated that get installed.

| Program | Weighted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|---|
| Retail (Time of Sale) | 87.5%[848] | 5.7% | 4.8% | 98.0%[849] |

Hours = Average hours of use per year

=1643 (4.5 hrs per day)[850]

**MID LIFE BASELINE ADJUSTMENT**

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, 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 adjustment factors are provided below.

| Lumen Range | Pre EISA WattsBase | Post EISA WattsBase | CFL Equivalent | Delta Watts Before EISA | Delta Watts After EISA | Mid Life Adjustment | Adjustment made from date |
|---|---|---|---|---|---|---|---|
| 1490-2600 | 100 | 72 | 25 | 75 | 47 | 63% | N/A (2012 is already post EISA) |
| 1050-1489 | 75 | 53 | 20 | 55 | 33 | 60% | June, 2013 |
| 750-1049 | 60 | 43 | 14 | 46 | 29 | 63% | June, 2014 |
| 310-749 | 40 | 29 | 11 | 29 | 18 | 62% | June, 2014 |

---

[848] 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[849] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[850] Updated results from above study, presented in 2005 memo;
http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtfinalresultsmemodelivered.pdf

For example, a 2 x 20W 1200 lumen lamp CFL fixture is purchased in 2012:

First Year Installs:

$\Delta kWh$ = ((150 - 40) / 1000) * 0.875 * 1643

= 158 kWh

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (158 * 0.6) 94.8 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

Second Year Installs:

$\Delta kWH_{2nd\ year}$ = ((106 - 40) / 1000) * 0.057 * 1643

= 6.2 kWh

Note since this is now being installed in 2013 the baseline is adjusted to 2*53W due to EISA legislation

Third Year Installs:

$\Delta kWH_{3rd\ year}$ = ((106 - 40) / 1000) * 0.048 * 1643

= 5.2 kWh.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta kW$ = ((WattsBase - WattsEE) / 1 000) * ISR * CF

Where:

CF = Summer Peak Coincidence Factor for measure.

= 0.4%[851]

Other factors as defined above

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[851] Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.

For example, a 2 x 20W 1200 lumen lamp CFL fixture is purchased in 2012:

$\Delta kW_{1st\ year}$ = ((150 - 40) / 1000) * 0.875 * 0.004

= 0.0004 kW

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

**NATURAL GAS SAVINGS**

N/A

**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 Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see 'RES CFL Fixture O&M calc.xls'). The key assumptions used in this calculation are documented below[852]:

|  | Standard Incandescent | Efficient Incandescent | CFL |
|---|---|---|---|
| Replacement Cost | $0.50 | $1.50 | $2.50 |
| Component Rated Life (hrs) | 1000 | 1000[853] | 8000 |

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

| | NPV of replacement costs per bulb | | | |
|---|---|---|---|---|
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
| 1490-2600 | $18.34 | $16.28 | $14.12 | |
| 1050-1489 | $17.36 | $16.28 | $14.12 | $1.90 |
| 750-1049 | $15.50 | $15.30 | $14.12 | |
| 310-749 | $15.50 | $15.30 | $14.12 | |

---

[852] See 'RES CFL Fixture O&M calc.xls' for more details.
[853] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| Lumen Range | Levelized annual replacement costs per bulb | | | Efficient |
| | Baseline | | | |
| | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $2.86 | $2.54 | $2.20 | |
| 1050-1489 | $2.71 | $2.54 | $2.20 | $0.30 |
| 750-1049 | $2.42 | $2.39 | $2.20 | |
| 310-749 | $2.42 | $2.39 | $2.20 | |

**MEASURE CODE: RS-LTG-EFIX-V01-060112**

## 7.5.5   Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture

### DESCRIPTION

An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is installed in an interior residential setting. This measure could relate to either a fixture replacement or new installation (i.e. time of sale).

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. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W 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 and the expected delay in clearing retail inventory, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure.  For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is an ENERGY STAR lighting interior fixture for pin-based compact fluorescent lamps.

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a standard incandescent interior fixture.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected life of an interior fixture is 20 years[854]. However due to the backstop provision in the Energy Independence and Security Act of 2007 that requires by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, the baseline replacement would become equivalent to a CFL in that year.  The expected

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[854] 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 ) gives 20 years for an interior fluorescent fixture.

measure life for CFL fixtures installed June 2012 – May 2013 is therefore assumed to be 8 years. For bulbs installed June 2013 – May 2014, this would be reduced to 7 years and should be reduced each year[855].

**DEEMED MEASURE COST**

The incremental cost for an interior fixture is assumed to be $32[856].

**DEEMED O&M COST ADJUSTMENTS[857]**

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

| | NPV of replacement costs per bulb | | | Efficient |
| | Baseline | | | |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $8.44 | $7.41 | $6.32 | $0.00 (No replacements within measure life) |
| 1050-1489 | $8.44 | $7.41 | $6.32 | |
| 750-1049 | $7.50 | $7.41 | $6.32 | |
| 310-749 | $7.50 | $7.41 | $6.32 | |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement costs per bulb | | | Efficient |
| | Baseline | | | |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $1.32 | $1.16 | $0.99 | $0.00 (No replacements within measure life) |
| 1050-1489 | $1.32 | $1.16 | $0.99 | |
| 750-1049 | $1.17 | $1.16 | $0.99 | |
| 310-749 | $1.17 | $1.16 | $0.99 | |

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 -

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[855] Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.
[856] ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for interior fixture (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/LightingCalculator.xlsx?b299-55ae&b299-55ae)
[857] See 'RES CFL Fixture O&M calc.xls' for more details.

2016) are presented below:

| | NPV of replacement costs | | | |
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $57.47 | $51.35 | $44.90 | |
| 1050-1489 | $52.62 | $51.35 | $44.90 | $4.89 |
| 750-1049 | $47.08 | $46.50 | $44.90 | |
| 310-749 | $47.08 | $46.50 | $44.90 | |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement cost savings | | | |
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $8.97 | $8.02 | $7.01 | |
| 1050-1489 | $8.22 | $8.02 | $7.01 | $0.76 |
| 750-1049 | $7.35 | $7.26 | $7.01 | |
| 310-749 | $7.35 | $7.26 | $7.01 | |

LOADSHAPE

  Loadshape R06 - Residential Indoor Lighting
  Loadshape C06 - Commercial Indoor Lighting[858]

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%[859] for Residential and in-unit Multi Family bulbs and 75%[860] for Multi Family common area bulbs.

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[858] For Multi Family common area lighting.

[859] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
 "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[860] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe$$

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

| Minimum Lumens | Maximum Lumens | Incandescent Equivalent Pre-EISA 2007 ($Watts_{Base}$) | Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$) | Effective date from which Post – EISA 2007 assumption should be used |
|---|---|---|---|---|
| 1490 | 2600 | 100 | 72 | June 2012 |
| 1050 | 1489 | 75 | 53 | June 2013 |
| 750 | 1049 | 60 | 43 | June 2014 |
| 310 | 749 | 40 | 29 | June 2014 |

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

| Program | Weighted Average 1st year In Service Rate (ISR) | 2nd year Installations | 3rd year Installations | Final Lifetime In Service Rate |
|---|---|---|---|---|
| Retail (Time of Sale) | 87.5%[861] | 5.7% | 4.8% | 98.0%[862] |

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[861] 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[862] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

Hours = Average hours of use per year

| Installation Location | Hours |
|---|---|
| Residential and in-unit Multi Family | 938 [863] |
| Multi Family Common Areas | 5950[864] |

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

| Bulb Location | WHFe |
|---|---|
| Interior single family or unknown location | 1.06 [865] |
| Multi family in unit | 1.04 [866] |
| Multi family common area | 1.04 [867] |
| Exterior or uncooled location | 1.0 |

**MID LIFE BASELINE ADJUSTMENT**

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

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[863] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

[864] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[865] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls)

[866] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls

[867] Ibid.

For example, for 60W equivalent bulbs installed in 2012, 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 adjustment factors are provided below.

| Lumen Range | Pre EISA WattsBase | Post EISA WattsBase | CFL Equivalent | Delta Watts Before EISA | Delta Watts After EISA | Mid Life Adjustment | Adjustment made from date |
|---|---|---|---|---|---|---|---|
| 1490-2600 | 100 | 72 | 25 | 75 | 47 | 63% | N/A (2012 is already post EISA) |
| 1050-1489 | 75 | 53 | 20 | 55 | 33 | 60% | June, 2013 |
| 750-1049 | 60 | 43 | 14 | 46 | 29 | 63% | June, 2014 |
| 310-749 | 40 | 29 | 11 | 29 | 18 | 62% | June, 2014 |

For example, a 2 x 20W 1200 lumen lamp CFL fixture is purchased in 2012 and installed in single family interior location:

First Year Installs:

$\Delta$kWh = ((150 - 40) / 1000) * 0.875 * 938 * 1.06

= 95.7 kWh

This value should be claimed in June 2012 – May 2013, but from June 2013 on savings for that same bulb should be reduced to (95.7 * 0.6 =) 57.4 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts.

Second Year Installs:

$\Delta$kWH$_{2nd\ year}$ = ((106 - 40) / 1000) * 0.057 * 938 * 1.06

= 3.7 kWh

Note since this is now being installed in 2013 the baseline is adjusted to 2*53W due to EISA legislation

Third Year Installs:

$\Delta$kWH$_{3rd\ year}$ = ((106 - 40) / 1000) * 0.048 * 938 * 1.06

= 3.1 kWh

**HEATING PENALTY**

If electric heated building:

$$\Delta kWh^{868} = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / \eta Heat$$

Where:

| | | |
|---|---|---|
| HF | = Heating Factor or percentage of light savings that must be heated | |
| | = 49%[869] for interior or unknown location | |
| | = 0% for unheated location | |
| $\eta$Heat | = Efficiency in COP of Heating equipment | |
| | = actual. If not available use[870]: | |

| System Type | Age of Equipment | HSPF Estimate | ηHeat (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

---

For example, a 2 x 20W 1200 lumen lamp CFL is purchased in 2012 and installed in home with 2.0 COP Heat Pump:

$$\Delta kWh_{1st\ year} = - (((150 - 40) / 1000) * 0.875 * 938 * 0.49) / 2.0$$

$$= - 22\ kWh$$

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment

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**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = ((WattsBase - WattsEE) / 1\ 000) * ISR * WHFd * CF$$

Where:

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[868] Negative value because this is an increase in heating consumption due to the efficient lighting.

[869] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[870] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

| Bulb Location | WHFd |
|---|---|
| Interior single family or unknown location | 1.11[871] |
| Multi family in unit | 1.07[872] |
| Multi family common area | 1.07[873] |
| Exterior or uncooled location | 1.0 |

CF = Summer Peak Coincidence Factor for measure.

| Bulb Location | CF |
|---|---|
| Interior single family or unknown location | 9.5%[874] |
| Multi family in unit | 9.5%[875] |
| Multi family common area | 75%[876] |

Other factors as defined above

For example, a 2 x 20W 1200 lumen lamp CFL is purchased in 2012 and installed in home with 2.0 COP Heat Pump:

$\Delta kW_{1st\ year}$ = ((150 - 40) / 1000) * 0.875 * 1.11 * 0.095

= 0.01 kW

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment.

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[871] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[872] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls .

[873] Ibid

[874] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
 "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[875] Ibid.

[876] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

**NATURAL GAS SAVINGS**

$\Delta Therms^{877}$ = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / $\eta$Heat

Where:

| | |
|---|---|
| HF | = Heating Factor or percentage of light savings that must be heated |
| | = 49%[878] for interior or unknown location |
| | = 0% for unheated location |
| 0.03412 | =Converts kWh to Therms |
| $\eta$Heat | = Efficiency of heating system |
| | =70%[879] |

---

For example, a 2 x 20W 1200 lumen lamp CFL is purchased in 2012 and installed in home with gas heat at 70% efficiency:

$\Delta Therms_{1st\ year}$  =  -((150 - 40) / 1000) * 0.875 * 938 * 0.49 * 0.03412) / 0.7

   = - 2.2 Therms

Second and third year savings should be calculated using the appropriate ISR and baseline shift adjustment

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**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 Energy Independence and Security Act of 2007, an equivalent

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[877] Negative value because this is an increase in heating consumption due to the efficient lighting.

[878] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[879] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) =  0.70

annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see 'RES CFL Fixture O&M calc.xls'). The key assumptions used in this calculation are documented below:

| | Standard Incandescent | Efficient Incandescent | CFL |
|---|---|---|---|
| Replacement Cost | $0.50 | $1.50 | $2.50 |
| Component Rated Life (hrs) | 1000 | 1000[880] | 8000 (or 10,000 for multifamily common areas) |

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

| | NPV of replacement costs per bulb | | | |
|---|---|---|---|---|
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
| 1490-2600 | $8.44 | $7.41 | $6.32 | $0.00 (No replacements within measure life) |
| 1050-1489 | $8.44 | $7.41 | $6.32 | |
| 750-1049 | $7.50 | $7.41 | $6.32 | |
| 310-749 | $7.50 | $7.41 | $6.32 | |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement costs per bulb | | | |
|---|---|---|---|---|
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
| 1490-2600 | $1.32 | $1.16 | $0.99 | $0.00 (No replacements within measure life) |
| 1050-1489 | $1.32 | $1.16 | $0.99 | |
| 750-1049 | $1.17 | $1.16 | $0.99 | |
| 310-749 | $1.17 | $1.16 | $0.99 | |

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

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[880] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

| | NPV of replacement costs | | | |
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $57.47 | $51.35 | $44.90 | |
| 1050-1489 | $52.62 | $51.35 | $44.90 | $4.89 |
| 750-1049 | $47.08 | $46.50 | $44.90 | |
| 310-749 | $47.08 | $46.50 | $44.90 | |

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

| | Levelized annual replacement cost savings | | | |
| | Baseline | | | Efficient |
| Lumen Range | June 2012 - May 2013 | June 2013 - May 2014 | June 2014 - May 2015 | All |
|---|---|---|---|---|
| 1490-2600 | $8.97 | $8.02 | $7.01 | |
| 1050-1489 | $8.22 | $8.02 | $7.01 | $0.76 |
| 750-1049 | $7.35 | $7.26 | $7.01 | |
| 310-749 | $7.35 | $7.26 | $7.01 | |

**MEASURE CODE: RS-LTG-IFIX-V01-060112**

## 7.5.6  LED Downlights

### DESCRIPTION

This measure describes savings from a variety of LED downlight lamp types. Other LED lamp types are currently available (e.g. A-lamps) but the significant incremental cost and minimal efficacy improvements over CFLs mean that they are unlikely to represent a viable measure at this time. As prices continue to drop and improvements in efficacy continue, this will be revisited in future versions.

This characterization assumes that the LED lamp or fixture is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

This measure was developed to be applicable to the following program types:  TOS, NC.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR LED lamp or fixture.

### DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be an incandescent/halogen lamp for all lamp types.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is given in the following table.[881]

| Bulb Type | Measure Life (yr) |
|---|---|
| PAR20, PAR30, PAR38 screw-in lamps | 10 |
| MR16/PAR16 pin-based lamps | 10 |
| Recessed downlight luminaries | 15 |
| Track lights | 15 |

---

[881] Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)

DEEMED MEASURE COST

The price of LED lamps is falling quickly. Where possible the actual cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following[882]:

| Bulb Type | Baseline Cost | LED Cost | Incremental Cost |
|---|---|---|---|
| PAR20, PAR30, PAR38 screw-in lamps | $4.00 | $44.00 | $40.00 |
| MR16/PAR16 pin-based lamps | $3.00 | $28.00 | $25.00 |
| Recessed downlight luminaries | $4.00 | $94.00 | $90.00 |
| Track lights | $4.00 | $60.00 | $56.00 |

DEEMED O&M COST ADJUSTMENTS

The life of the baseline bulb and the cost of its replacement is presented in the following table:

| Lamp Type | Baseline Lamp Life (hours) | Baseline Life (years) (Single Family and in unit Multifamily - 1010 hours) | Baseline Life (years) (Common Area Multifamily - 5950 hours) | Baseline Replacement Cost |
|---|---|---|---|---|
| PAR20, PAR30, PAR38 screw-in lamps | 2000 | 2.0 | 0.3 | $4.00 |
| MR16/PAR16 pin-based lamps | 2000 | 2.0 | 0.3 | $3.00 |
| Recessed downlight luminaries | 2000 | 2.0 | 0.3 | $4.00 |
| Track lights | 2000 | 2.0 | 0.3 | $4.00 |

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Loadshape C06 - Commercial Indoor Lighting[883]

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 9.5%[884] for Residential and in-unit Multi Family bulbs and 75%[885] for Multi Family common area bulbs.

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[882] Costs are provided as the best estimate from VEIC and are based on review of available product and of price reports provided to Efficiency Vermont by a number of manufacturers and retailers.

[883] For Multi Family common area lighting.

[884] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[885] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with

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**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh    = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase        = Baseline lamp wattage of equivalent lumens, see "Bulb Types" table – default baseline assumption (incandescent/halogen) is in bold and highlighted yellow

WattsEE        = Actual wattage of energy efficient LED lamp purchased

| Bulb Type | Efficacy (lumen/Watt)[886] | Lumens | LED Watts (WattsEE) | Incandescent/ Halogen Watts | EISA compliant Incandescent Watts | CFL Watts |
|---|---|---|---|---|---|---|
| PAR20 screw-in lamps | 10-15 (incandescent/halogen) 35-45 (CFL reflector) 40-60 (LED) | 460-810 | 13 | **46** | | 18 |
| PAR30 screw-in lamps | | 600-1005 | 15 | **67** | | 20 |
| PAR38 screw-in lamps | | 630-1170 | 18 | **78** | | 23 |
| MR16/PAR16 pin-based lamps | 15-25 (Incandescent) 50 (LED) | 300-500 | 8 | **20** | | |
| | | 525-875 | 14 | **35** | | |
| | | 750-1250 | 20 | **50** | | |
| Recessed downlight luminaries | 35 (fixture efficacy with a CFL lamp) 42-86 (LED fixture) | 540 | 11 | **50** | | 15 |
| | | 500-650 | 12 | **65** | | 18 |
| | | 1000 | 13 | **100** | | 25 |
| Track lights (R20) | 10-15 [887] (incandescent/halogen) 35-45 (CFL reflector) 40-60 (LED) | 320-675 | 8 | **45** | | 10 |
| Track lights (BR30 and BR40) | | 440-975 | 11 | **65** | | 18 |

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similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

[886] Data source for most efficacies: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, Navigrant Consulting, January 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_january2011.pdf

[887] The exemption to EISA for reflector bulbs is expected to expire in 2014 for the following wattage and bulb type: 45 W (R20 and BR 19); 50W (R30, ER 30, BR 40, and ER 40); 65W (BR30, BR40, and ER 404)

ISR = In Service Rate or the percentage of units rebated that get installed[888]

| Bulb Type | ISR |
|---|---|
| PAR20, PAR30, PAR38 screw-in lamps | 0.95 |
| MR16/PAR16 pin-based lamps | 0.95 |
| Recessed downlight luminaries | 1.0 |
| Track lights | 1.0 |

Hours = Average hours of use per year

| Installation Location | Hours |
|---|---|
| Residential and in-unit Multi Family | 1,010 [889] |
| Multi Family Common Areas | 5950[890] |

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

| Bulb Location | WHFe |
|---|---|
| Interior single family or unknown location | 1.06 [891] |
| Multi family in unit | 1.04 [892] |
| Multi family common area | 1.04 [893] |
| Exterior or uncooled location | 1.0 |

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

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[888] NEEP EMV Emerging Technologies Research Report (December 2011)

[889] NEEP EMV Emerging Technologies Research Report (December 2011)

[890] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[891] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls)

[892] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls

[893] Ibid.

$\Delta$kWh     = ((46 - 13) / 1000) * 0.95 * 1010 * 1.06

          = 33.6 kWh

**HEATING PENALTY**

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$\Delta$kWh[894]  = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / $\eta$Heat

Where:

HF        = Heating Factor or percentage of light savings that must be heated

          = 49%[895] for interior or unknown location

          = 0% for exterior location

$\eta$Heat    = Efficiency in COP of Heating equipment

          = Actual. If not available use:[896]

| System Type | Age of Equipment | HSPF Estimate | ηHeat (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
|  | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

    $\Delta$kWh     = - ((46 - 13) / 1000) * 0.95 * 1010 * 0.49) / 2.26

            = - 6.87 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

    $\Delta$kW = ((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF

---

[894] Negative value because this is an increase in heating consumption due to the efficient lighting.
[895] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.
[896] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

| Bulb Location | WHFd |
|---|---|
| Interior single family or unknown location | 1.11[897] |
| Multi family in unit | 1.07[898] |
| Multi family common area | 1.07 [899] |
| Exterior or uncooled location | 1.0 |

CF = Summer Peak Coincidence Factor for measure, see above for values.

| Bulb Location | CF |
|---|---|
| Interior single family or unknown location | 9.5% [900] |
| Multi family in unit | 9.5% [901] |
| Multi family common area | 75% [902] |

Other factors as defined above

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For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

$\Delta kW$ = ((46 - 13) / 1000) * 0.95 * 1.11* 0.095

= 0.0033 kW

---

[897] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[898] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

[899] Ibid

[900] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf "Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[901] Ibid.

[902] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

**NATURAL GAS SAVINGS**

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$\Delta$therms $\quad = -$ (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / $\eta$Heat

Where:

HF $\quad$ = Heating factor, or percentage of lighting savings that must be replaced by heating system.

$\quad$ = 49% [903] for interior or unknown location

$\quad$ = 0% for exterior location

0.03412 $\quad$ = Converts kWh to Therms

$\eta$Heat $\quad$ = Average heating system efficiency.

$\quad$ = 0.70 [904]

Other factors as defined above

---

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location with gas heating at 70% total efficiency:

$\Delta$therms $\quad = -$ (((46 - 13) / 1000) * 0.95 * 1010 * 0.49* 0.03412) / 0.70

$\quad = -$ 0.756 therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

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[903] Average result from REMRate modeling of several different configurations and IL locations of homes

[904] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:
http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

**DEEMED O&M COST ADJUSTMENT CALCULATION**

The life of the baseline bulb and the cost of its replacement is presented in the following table:

| Lamp Type | Baseline Lamp Life (hours) | Baseline Life (Single Family and in unit Multifamily - 1010 hours) | Baseline Life (Common Area Multifamily - 5950 hours) | Baseline Replacement Cost |
|---|---|---|---|---|
| PAR20, PAR30, PAR38 screw-in lamps | 2000 | 2.0 | 0.3 | $4.00 |
| MR16/PAR16 pin-based lamps | 2000 | 2.0 | 0.3 | $3.00 |
| Recessed downlight luminaries | 2000 | 2.0 | 0.3 | $4.00 |
| Track lights | 2000 | 2.0 | 0.3 | $4.00 |

**MEASURE CODE: RS-LTG-LEDD-V01-060112**

## 7.5.7   LED Exit Signs

### DESCRIPTION

This measure assumes characterizes the savings associated with installing a Light Emitting Diode (LED) exit sign in place of a fluorescent or incandescent exit sign in a MultiFamily. Light Emitting Diode 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.

This measure was developed to be applicable to the following program types:  TOS, NC, RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is assumed to be an exit sign illuminated by LEDs.

### DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a fluorescent or incandescent model.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 16 years[905].

### DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $30[906].

### DEEMED O&M COST ADJUSTMENTS

The annual O&M Cost Adjustment savings is calculated using component costs and lifetimes presented below.

### LOADSHAPE

Loadshape C53 - Flat

### COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100%[907].

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[905] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[906] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[907] Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.

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**Algorithm**

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CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * HOURS * WHF_e$$

Where:

WattsBase = Actual wattage if known, if unknown assume the following:

| Baseline Type | WattsBase |
|---|---|
| Incandescent | 35W[908] |
| Fluorescent | 11W[909] |
| Unknown (e.g. time of sale) | 11W |

WattsEE = Actual wattage if known, if unknown assume 2W[910]

HOURS = Annual operating hours

= 8766

WHF$_e$ = Waste heat factor for energy; accounts for cooling savings from efficient lighting.

= 1.04[911] for multi family buildings

Default if replacing incandescent fixture

$$\Delta kWH = (35 - 2)/1000 * 8766 * 1.04$$

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[908] Based on review of available product.

[909] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[910] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[911] The value is estimated at 1.04 (calculated as 1 + (0.45*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 3.1 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average);
http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls

---

= 301 kWh

Default if replacing fluorescent fixture

$\Delta$kWH = (11 − 2)/1000 * 8766 * 1.04

= 82 kWh

## HEATING PENALTY

If electric heated building (if heating fuel is unknown assume gas, see Natural Gas section):

$\Delta$kWh[912] = - (((WattsBase - WattsEE) / 1000) * Hours * HF) / $\eta$Heat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[913]

$\eta$Heat = Efficiency in COP of Heating equipment

= Actual. If not available use:[914]

| System Type | Age of Equipment | HSPF Estimate | $\eta$Heat (COP Estimate) |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| | After 2006 | 7.7 | 2.26 |
| Resistance | N/A | N/A | 1.00 |

For example, a 2.0COP Heat Pump heated building:

If incandescent fixture: $\Delta$kWH = -((35 − 2)/1000 * 8766 * 0.49) / 2

= -71 kWh

If fluorescent fixture $\Delta$kWH = -((11 − 2)/1000 * 8766 * 0.49) / 2

= -19 kWh

---

[912] Negative value because this is an increase in heating consumption due to the efficient lighting.

[913] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[914] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = ((WattsBase - WattsEE) / 1000) * WHF_d * CF$$

Where:

$WHF_d$ = Waste heat factor for demand to account for cooling savings from efficient lighting. The cooling savings are only added to the summer peak savings.

= 1.07 [915] for multi family buildings

CF = Summer Peak Coincidence Factor for measure

= 1.0

Default if incandescent fixture

$\Delta kW$ = (35 – 2)/1000 * 1.07 * 1.0

= 0.035 kW

Default if fluorescent fixture

$\Delta kW$ = (11 – 2)/1000 * 1.07 * 1.0

= 0.0096 kW

**NATURAL GAS SAVINGS**

Heating penalty if Natural Gas heated building, or if heating fuel is unknown.

$\Delta therms$ = - (((WattsBase - WattsEE) / 1000) * Hours * HF * 0.03412) / $\eta Heat$

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [916]

0.03412 = Converts kWh to Therms

$\eta Heat$ = Average heating system efficiency.

= 0.70 [917]

---

[915] The value is estimated at 1.11 (calculated as 1 + (0.45 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[916] Average result from REMRate modeling of several different configurations and IL locations of homes

Other factors as defined above

Default if incandescent fixture

$$\Delta therms = - (((35 - 2) / 1000) * 8766 * 0.49 * 0.03412) / 0.70$$

$$= -6.9 \text{ therms}$$

Default if fluorescent fixture

$$\Delta therms = - (((11 - 2) / 1000) * 8766 * 0.49 * 0.03412) / 0.70$$

$$= -1.9 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The annual O&M Cost Adjustment savings should be calculated using the following component costs and lifetimes.

| Component | Baseline Measures | |
| --- | --- | --- |
| | Cost | Life (yrs) |
| Lamp | $7.00[918] | 1.37 years[919] |

MEASURE CODE: RS-LTG-LEDE-V01-060112

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[917] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:
http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70
[918] Consistent with assumption for a Standard CFL bulb with an estimated labor cost of $4.50 (assuming $18/hour and a task time of 15 minutes).
[919] Assumes a lamp life of 12,000 hours and 8766 run hours 12000/8766 = 1.37 years.

# 7.6   Shell End Use

## 7.6.1   Air Sealing

**DESCRIPTION**

Thermal shell air leaks are sealed through strategic use and location of air-tight materials.  Leaks are detected and leakage rates measured with the assistance of a blower-door.

This measure was developed to be applicable to the following program types:  RF.
If applied to other program types, the measure savings should be verified.

**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 using a blower door.  The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing.

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The expected measure life is assumed to be 15 years.[920]

**DEEMED MEASURE COST**

The actual capital cost for this measure should be used in screening.

**DEEMED O&M COST ADJUSTMENTS**

N/A

**LOADSHAPE**

  Loadshape R08 - Residential Cooling
  Loadshape R09 - Residential Electric Space Heat
  Loadshape R10 - Residential Electric Heating and Cooling

**COINCIDENCE FACTOR**

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second

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[920] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 91.5%[921]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[922]

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to air sealing

= [(((CFM50_existing - CFM50_new)/N_cool) * 60 * 24 * CDD * DUA * 0.018) / (1000 * ηCool)] * LM

CFM50_existing = Infiltration at 50 Pascals as measured by blower door before air sealing.

= Actual

CFM50_new = Infiltration at 50 Pascals as measured by blower door after air sealing.

= Actual

---

[921] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[922] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

---

N_cool          = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

=Dependent on exposure:[923]

| Climate Zone | Exposure | N-Factor |
|---|---|---|
| Zone 2 | Well Shielded | 22.2 |
| | Normal | 18.5 |
| | Exposed | 16.7 |
| Zone 3 | Well Shielded | 25.8 |
| | Normal | 21.5 |
| | Exposed | 19.4 |

60 * 24          = Converts Cubic Feet per Minute to Cubic Feet per Day

CDD          = Cooling Degree Days

= Dependent on location[924]:

| Climate Zone (City based upon) | CDD 65 |
|---|---|
| 1 (Rockford) | 820 |
| 2 (Chicago) | 842 |
| 3 (Springfield) | 1,108 |
| 4 (Belleville) | 1,570 |
| 5 (Marion) | 1,370 |

DUA          = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [925]

0.018          = Specific Heat Capacity of Air (BTU/ft$^3$*°F)

1000          = Converts Btu to kBtu

---

[923] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and exposure of the home to wind (impacts of stack effect based on height of building will not be significant because of reduced delta T during the cooling season) , based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

[924] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.

[925] This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following[926]:

| Age of Equipment | SEER Estimate |
|---|---|
| Before 2006 | 10 |
| After 2006 | 13 |

LM = Latent multiplier to account for latent cooling demand

= dependent on location: [927]

| Climate Zone (City based upon) | LM |
|---|---|
| 1 (Rockford) | 8.5 |
| 2 (Chicago) | 6.2 |
| 3 (Springfield) | 6.6 |
| 4 (St. Louis, MO) | 5.8 |
| 5 (Evansville, IN) | 6.6 |

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing

$$= (((CFM50\_existing - CFM50\_new)/N\_heat) * 60 * 24 * HDD * 0.018) / (\eta Heat * 3,412)$$

---

[926] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

[927] The Latent Multiplier is used to convert the sensible cooling savings calculated to a value representing sensible and latent cooling loads. The values are derived from Harriman et al "Dehumidification and Cooling Loads From Ventilation Air", ASHRAE Journal, by adding the latent and sensible loads to determine the total, then dividing the total by the sensible load. Where this specialized data was not available, a nearby city was chosen.

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone, building height and exposure level:[928]

| | # Stories: | 1 | 1.5 | 2 | 3 |
|---|---|---|---|---|---|
| Zone 2 | Well Shielded | 22.2 | 20.0 | 17.8 | 15.5 |
| | Normal | 18.5 | 16.7 | 14.8 | 13.0 |
| | Exposed | 16.7 | 15.0 | 13.3 | 11.7 |
| Zone 3 | Well Shielded | 25.8 | 23.2 | 20.6 | 18.1 |
| | Normal | 21.5 | 19.4 | 17.2 | 15.1 |
| | Exposed | 19.4 | 17.4 | 15.5 | 13.5 |

HDD = Heating Degree Days

= Dependent on location:[929]

| Climate Zone (City based upon) | HDD 60 |
|---|---|
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |

---

[928] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location, height of building (stack effect) and exposure of the home to wind, based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

[929] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004.

ηHeat  = Efficiency of heating system

= Actual. If not available refer to default table below[930]:

| System Type | Age of Equipment | HSPF Estimate | ηHeat (Effective COP Estimate)= (HSPF/3.413)*0.85 |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 1.7 |
| | After 2006 | 7.7 | 1.92 |
| Resistance | N/A | N/A | 1 |

3412  = Converts Btu to kWh

---

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2 (1.92 including distribution losses), has pre and post blower door test results of 3,400 and 2,250:

ΔkWh  = ΔkWh_cooling + ΔkWh_heating

= [((((3,400 − 2,250) / 22.2) * 60 * 24 * 842 * 0.75 * 0.018) / (1000 * 10.5)) * 6.2] + [((3,400 − 2,250) / 17.8)) * 60 * 24 * 5113 * 0.018 / (1.92 * 3,412)]

= 501 + 1307

= 1,808 kWh

---

[930] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$\Delta$kW = ($\Delta$kWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[931]:

| Climate Zone (City based upon) | Single Family | Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[932]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[933]

Other factors as defined above

---

[931] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH.

[932] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[933] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2.0, has pre and post blower door test results of 3,400 and 2,250:

$\Delta kW_{SSP}$ = 501 / 570 * 0.915

= 0.804 kW

$\Delta kW_{PJM}$ = 501 / 570 * 0.466

= 0.410 kW

**NATURAL GAS SAVINGS**

If Natural Gas heating:

$\Delta$Therms = (((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / ($\eta$Heat * 100,000)

Where:

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone, building height and exposure level[934]:

| # Stories: | | 1 | 1.5 | 2 | 3 |
|---|---|---|---|---|---|
| Zone 2 | Well Shielded | 22.2 | 20.0 | 17.8 | 15.5 |
| | Normal | 18.5 | 16.7 | 14.8 | 13.0 |
| | Exposed | 16.7 | 15.0 | 13.3 | 11.7 |
| Zone 3 | Well Shielded | 25.8 | 23.2 | 20.6 | 18.1 |
| | Normal | 21.5 | 19.4 | 17.2 | 15.1 |
| | Exposed | 19.4 | 17.4 | 15.5 | 13.5 |

---

[934] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location, height of building (stack effect) and exposure of the home to wind, based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

HDD          = Heating Degree Days

                 = dependent on location[935]:

| Climate Zone (City based upon) | HDD 60 |
|---|---|
| 1 (Rockford) | 820 |
| 2 (Chicago) | 842 |
| 3 (Springfield) | 1,108 |
| 4 (Belleville) | 1,570 |
| 5 (Marion) | 1,370 |

$\eta$Heat        = Efficiency of heating system

                 = Equipment efficiency * distribution efficiency

                 = Actual[936]. If not available use 70%[937].

Other factors as defined above

---

For example, a well shielded, 2 story single family home in Chicago with a gas furnace with system efficiency of 70%, has pre and post blower door test results of 3,400 and 2,250:

         $\Delta$Therms        = ((3,400 – 2,250)/17.8) * 60 * 24 * 5113 * 0.018) / (0.7 * 100,000)

                             = 122 therms

---

[935] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004..

[936] Ideally, the System Efficiency should 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.

[937] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:

http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls )

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) =  0.70

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**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-AIRS-V01-060112**

## 7.6.2 Basement Sidewall Insulation

### DESCRIPTION

Insulation is added to a basement or crawl space. Insulation added above ground in conditioned space is modeled the same as wall insulation. Below ground insulation is adjusted with an approximation of the thermal resistance of the ground. Insulation in unconditioned spaces is modeled by reducing the degree days to reflect the smaller but non-zero contribution to heating and cooling load. Cooling savings only consider above grade insulation, as below grade has little temperature difference during the cooling season.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

### DEFINITION OF BASELINE EQUIPMENT

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no basement wall or ceiling insulation.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[938].

### DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

### COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid

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[938] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[939]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[940]

---

**Algorithm**

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**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= (((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * ηCool))

R_added = R-value of additional spray foam, rigid foam, or cavity insulation.

R_old_AG = R-value value of foundation wall above grade.

= 2.25 [941]

L_basement_wall_total = Length of basement wall around the entire insulated perimeter (ft)

H_basement_wall_AG = Height of insulated basement wall above grade (ft)

Framing_factor = Adjustment to account for area of framing when cavity insulation is used

= 0% if Spray Foam or External Rigid Foam

= 15% if studs and cavity insulation[942]

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[939] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[940] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
[941] ORNL Builders Foundation Handbook, crawl space data from Table 5-5: Initial Effective R-values for Uninsulated Foundation System and Adjacent Soil, 1991, http://www.ornl.gov/sci/roofs+walls/foundation/ORNL_CON-295.pdf
[942] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.

24 = Converts hours to days

CDD = Cooling Degree Days

= Dependent on location and whether basement is conditioned:[943]

| Climate Zone (City based upon) | Conditioned CDD 65 | Unconditioned CDD 65[944] |
|---|---|---|
| 1 (Rockford) | 820 | 263 |
| 2 (Chicago) | 842 | 281 |
| 3 (Springfield) | 1,108 | 436 |
| 4 (Belleville) | 1,570 | 538 |
| 5 (Marion) | 1,370 | 570 |
| Weighted Average[945] | 947 | 325 |

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [946]

1000 = Converts Btu to kBtu

$\eta$Cool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:[947]

| Age of Equipment | $\eta$Cool Estimate |
|---|---|
| Before 2006 | 10 |
| After 2006 | 13 |

$\Delta$kWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= [((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG *

---

[943] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[944] Five year average cooling degree days with 75F base temp from DegreeDays.net were used in this table because the 30 year climate normals from NCDC used elsewhere are not available at base temps above 72F.
[945] Weighted based on number of occupied residential housing units in each zone.
[946] This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.
[947] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

(1-Framing_factor)) + ((1/(R_old_BG - 1/(R_added+R_old_BG)) * L_basement_wall_total * (H_basement_wall_total - H_basement_wall_AG) * (1-Framing_factor))] * 24 * HDD) / (3,412 * ηHeat))

R_old_BG = R-value value of foundation wall below grade (including thermal resistance of the earth) [948]

= dependent on depth of foundation (H_basement_wall_total – H_basement_wall_AG):

| Below Grade R-value | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth below grade (ft) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Earth R-value ($°F\text{-}ft^2\text{-}h/Btu$) | 2.44 | 4.50 | 6.30 | 8.40 | 10.44 | 12.66 | 14.49 | 17.00 | 20.00 |
| Average Earth R-value ($°F\text{-}ft2\text{-}h/Btu$) | 2.44 | 3.47 | 4.41 | 5.41 | 6.42 | 7.46 | 8.46 | 9.53 | 10.69 |
| Total BG R-value (earth + R-2.25 foundation) | 4.69 | 5.72 | 6.66 | 7.66 | 8.67 | 9.71 | 10.71 | 11.78 | 12.94 |

H_basement_wall_total = Total height of basement wall (ft)

HDD = Heating Degree Days

= dependent on location and whether basement is conditioned[949]:

| Climate Zone (City based upon) | Conditioned HDD 60 | Unconditioned HDD 50 |
|---|---|---|
| 1 (Rockford) | 5,352 | 3,322 |
| 2 (Chicago) | 5,113 | 3,079 |
| 3 (Springfield) | 4,379 | 2,550 |
| 4 (Belleville) | 3,378 | 1,789 |
| 5 (Marion) | 3,438 | 1,796 |
| Weighted Average[950] | 4,860 | 2,895 |

---

[948] Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook

[949] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F for a conditioned basement and 50°F for an unconditioned basement), consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[950] Weighted based on number of occupied residential housing units in each zone.

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[951]:

| System Type | Age of Equipment | HSPF Estimate | ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85 |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 1.7 |
| | After 2006 | 7.7 | 1.92 |
| Resistance | N/A | N/A | 1 |

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

= [(((1/2.25 - 1/(13 + 2.25))*(20+25+20+25) * 3 * (1 - 0)) * 24 * 281 * 0.75)/(1000 * 10.5)] + [((((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0)) + ((1 / 8.67 − 1 / (13 + 8.67)) * (20+25+20+25) * 4 * (1-0))) * 24 * 3079) / (3412 * 1.92)]

= 49.3 + 1435

= 1480 kWh

**SUMMER COINCIDENT PEAK DEMAND**

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

---

[951] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

FLH_cooling      = Full load hours of air conditioning

= dependent on location[952]:

| Climate Zone (City based upon) | Single Family | Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[953] | 629 | 564 |

$CF_{SSP}$      = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[954]

$CF_{PJM}$      = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[955]

---

For example, a single family home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

$\Delta kW_{SSP}$ = 49.3 / 570 * 0.915

= 0.0791 kW

$\Delta kW_{PJM}$ = 49.3 / 570 * 0.466

= 0.0403 kW

---

[952] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[953] Weighted based on number of occupied residential housing units in each zone.

[954] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[955] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

**NATURAL GAS SAVINGS**

If Natural Gas heating:

ΔTherms = ((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor) + (1/(R_old_BG - 1/(R_added+R_old_BG)) * L_basement_wall_total * (H_basement_wall_total - H_basement_wall_AG) * (1-Framing_factor)] * 24 * HDD) / (ηHeat * 100,067)

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[956]

Other factors as defined above

---

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 70% efficient furnace:

= ((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0) + (1/8.67 - 1/(13 + 8.67)) * (20+25+20+25) * 4 * (1 - 0)) * 24 * 3079) / (0.7 * 100,067)

= 134 therms

---

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-BINS-V01-060112**

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[956] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey:
http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

## 7.6.3    Floor insulation above crawlspace

### DESCRIPTION

Insulation is added to the floor above a vented crawl space that does not contain pipes or HVAC equipment. If there are pipes, HVAC, or a basement, it is desirable to keep them within the conditioned space by insulating the crawl space walls and ground. Insulating the floor separates the conditioned space above from the space below the floor, and is only acceptable when there is nothing underneath that could freeze or would operate less efficiently in an environment resembling the outdoors. Even in the case of an empty, unvented crawl space, it is still considered best practice to seal and insulate the crawl space perimeter rather than the floor. Not only is there generally less area to insulate this way, but there are also moisture control benefits. There is a "Basement Insulation" measure for perimeter sealing and insulation. This measure assumes the insulation is installed above an unvented crawl space and should not be used in other situations.

This measure was developed to be applicable to the following program types:  RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

### DEFINITION OF BASELINE EQUIPMENT

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no insulation on any surface surrounding a crawl space.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[957].

### DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

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[957] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

$CF_{SSP}$    = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 91.5%[958]

$CF_{PJM}$    = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[959]

---

**Algorithm**

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CALCULATION OF SAVINGS

Electric ENERGY SAVINGS

ΔkWh     = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling    = If central cooling, reduction in annual cooling requirement due to insulation

= (((1/R_old - 1/(R_added+R_old)) * Area * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * ηCool))

R_old       = R-value value of floor before insulation, assuming 3/4" plywood subfloor and carpet with pad

= 4.94 [960]

R_added     = R-value of additional spray foam, rigid foam, or cavity insulation.

Area        = Total floor area to be insulated

Framing_factor    = Adjustment to account for area of framing

---

[958] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[959] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[960] Based on 2005 ASHREA Handbook – Fundamentals: assuming 2x8 joists, 16" OC, ¾" subfloor, ½" carpet with rubber pad, and accounting for a still air film above and below: 0.85 cavity share of area * (0.68 + 0.94 + 1.23 + 0.68) + 0.15 framing share * (0.68 + 7.5" * 1.25 R/in + 0.94 + 1.23 + 0.68) = 4.94

$\qquad$ = 15% [961]

24 $\qquad$ = Converts hours to days

CDD $\qquad$ = Cooling Degree Days

| Climate Zone (City based upon) | Unconditioned CDD[962] |
|---|---|
| 1 (Rockford) | 263 |
| 2 (Chicago) | 281 |
| 3 (Springfield) | 436 |
| 4 (Belleville) | 538 |
| 5 (Marion) | 570 |
| Weighted Average[963] | 325 |

DUA $\qquad$ = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

$\qquad$ = 0.75 [964]

1000 $\qquad$ = Converts Btu to kBtu

ηCool $\qquad$ = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

$\qquad$ = Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:[965]

| Age of Equipment | ηCool Estimate |
|---|---|
| Before 2006 | 10 |
| After 2006 | 13 |

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= ((1/R_old - 1/(R_added + R_old)) * Area * (1-Framing_factor) * 24 * HDD)/ (3,412 * ηHeat))

---

[961] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.
[962] Five year average cooling degree days with 75F base temp from DegreeDays.net were used in this table because the 30 year climate normals from NCDC used elsewhere are not available at base temps above 72F.
[963] Weighted based on number of occupied residential housing units in each zone.
[964] Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.
[965] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

HDD        = Heating Degree Days[966]

| Climate Zone (City based upon) | Unconditioned HDD |
|---|---|
| 1 (Rockford) | 3,322 |
| 2 (Chicago) | 3,079 |
| 3 (Springfield) | 2,550 |
| 4 (Belleville) | 1,789 |
| 5 (Marion) | 1,796 |
| Weighted Average[967] | 2,895 |

ηHeat        = Efficiency of heating system

= Actual. If not available refer to default table below:[968]

| System Type | Age of Equipment | HSPF Estimate | ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85 |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 1.7 |
| | After 2006 | 7.7 | 1.92 |
| Resistance | N/A | N/A | 1 |

Other factors as defined above

---

For example, a home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

ΔkWh     = ΔkWh_cooling + ΔkWh_heating

$$=(((1/4.94-1/(30+4.94))*(20*25)*(1-0.15)* 24 * 281*0.75)/(1000*10.5) + ((1/4.94-1/(30+4.94))*(20*25)*(1-0.15) * 24 * 3079)/(3412*1.92)$$

= 35.6 + 833

= 869 kWh

---

[966] National Climatic Data Center, Heating Degree Days with a base temp of 50°F to account for lower impact of unconditioned space on heating system. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[967] Weighted based on number of occupied residential housing units in each zone.

[968] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW = (\Delta kWh\_cooling / FLH\_cooling) * CF$$

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[969]:

| Climate Zone (City based upon) | Single Family | Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[970] | 629 | 564 |

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[971]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[972]

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[969] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[970] Weighted based on number of occupied residential housing units in each zone.

[971] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[972] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

$\Delta kW_{SSP}$ = 35.6 / 570 * 0.915

= 0.057 kW

$\Delta kW_{SSP}$ = 35.6 / 570 * 0.466

= 0.029 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

$\Delta$Therms = (1/R_old - 1/(R_added+R_old)) * Area * (1-Framing_factor)) * 24 * HDD) / (100,000 * ηHeat) *

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[973]

Other factors as defined above

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace:

$\Delta$Therms = (1 / 4.94 – 1 /(30 + 4.94))*(20 * 25) * (1 - 0.15) * 24 * 3079) / (100,000 * 0.70)

= 78.0 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

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[973] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) =  0.70

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-FINS-V01-060112**

## 7.6.4   Wall and Ceiling/Attic Insulation

### DESCRIPTION

Insulation is added to wall cavities, and/or attic. This measure requires a member of the implementation staff evaluating the pre and post R-values and measure surface areas. The efficiency of the heating and cooling equipment in the home should also be evaluated if possible.

This measure was developed to be applicable to the following program types:  RF.
If applied to other program types, the measure savings should be verified.

### DEFINITION OF EFFICIENT EQUIPMENT

 This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

### DEFINITION OF BASELINE EQUIPMENT

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be empty wall cavities and little or no attic insulation.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[974].

### DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

  Loadshape R08 - Residential Cooling
  Loadshape R09 - Residential Electric Space Heat
  Loadshape R10 - Residential Electric Heating and Cooling

### COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market.  Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

---

[974] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[975]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[976]

---

**Algorithm**

---

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh$ = $\Delta kWh\_cooling$ + $\Delta kWh\_heating$

Where:

$\Delta kWh\_cooling$ = If central cooling, reduction in annual cooling requirement due to insulation

= [((1/R_old - 1/R_wall) * A_wall * (1-Framing_factor) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor/2)) * 24 * CDD * DUA] / (1000 * ηCool)

R_wall = R-value of new wall assembly (including all layers between inside air and outside air).

R_attic = R-value of new attic assembly (including all layers between inside air and outside air).

R_old = R-value value of existing assemble and any existing insulation.

(Minimum of R-5 for uninsulated assemblies[977])

A_wall = Total area of insulated wall (ft$^2$)

A_attic = Total area of insulated ceiling/attic (ft$^2$)

Framing_factor = Adjustment to account for area of framing

= 15%[978]

---

[975] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[976] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[977] An estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX).

[978] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation. Factor is used directly for walls, but reduced by 1/2 for attics, assuming that the average joist is 5.5" and R-38 requires 11" of cellulose, therefore at each joist, 1/2 the thickness of insulation has been added as between the joists.

24 = Converts hours to days

CDD = Cooling Degree Days

= dependent on location[979]:

| Climate Zone (City based upon) | CDD 65 |
|---|---|
| 1 (Rockford) | 820 |
| 2 (Chicago) | 842 |
| 3 (Springfield) | 1,108 |
| 4 (Belleville) | 1,570 |
| 5 (Marion) | 1,370 |
| Weighted Average[980] | 947 |

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [981]

1000 = Converts Btu to kBtu

ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following[982]:

| Age of Equipment | ηCool Estimate |
|---|---|
| Before 2006 | 10 |
| After 2006 | 13 |

kWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= [(1/R_old - 1/R_wall) * A_wall * (1-Framing_factor) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor/2)) * 24 * HDD] / (ηHeat * 3412)

---

[979] National Climatic Data Center, Cooling Degree Days are based on a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[980] Weighted based on number of occupied residential housing units in each zone.

[981] This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

[982] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

HDD = Heating Degree Days

= Dependent on location[983]:

| Climate Zone (City based upon) | HDD 60 |
|---|---|
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |
| Weighted Average[984] | 4,860 |

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[985]:

| System Type | Age of Equipment | HSPF Estimate | ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85 |
|---|---|---|---|
| Heat Pump | Before 2006 | 6.8 | 1.7 |
| | After 2006 | 7.7 | 1.92 |
| Resistance | N/A | N/A | 1 |

3412 = Converts Btu to kWh

---

[983] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[984] Weighted based on number of occupied residential housing units in each zone.

[985] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

For example, a single family home in Chicago with 990 ft$^2$ of R-5 walls insulated to R-11 and 700 ft$^2$ of R-5 attic insulated to R-38, 10.5 SEER Central AC and 2.26 (1.92 including distribution losses) COP Heat Pump:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

= [(((1/5 - 1/11) * 990 * (1-0.15)) + ((1/5 - 1/38) * 700 * (1-0.15/2)) * 842 * 0.75 * 24)/ (1000 * 10.5)] + [(((1/5 - 1/11) * 990 * (1-0.15)) + (1/5 - 1/38) * 700 * (1-0.15/2)) * 5113 * 24) / (1.92 * 3412

= 295 + 3826

= 4120 kWh

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location as below[986]:

| Climate Zone (City based upon) | Single Family | Multifamily |
|---|---|---|
| 1 (Rockford) | 512 | 467 |
| 2 (Chicago) | 570 | 506 |
| 3 (Springfield) | 730 | 663 |
| 4 (Belleville) | 1,035 | 940 |
| 5 (Marion) | 903 | 820 |
| Weighted Average[987] | 629 | 564 |

$CF_{SSP}$ = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[988]

$CF_{PJM}$ = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[989]

---

[986] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[987] Weighted based on number of occupied residential housing units in each zone.

[988] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[989] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The

For example, a single family home in Chicago with 990 ft$^2$ of R-5 walls insulated to R-11 and 700 ft$^2$ of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

$$\Delta kW_{SSP} = 295 / 570 * 0.915$$

$$= 0.474 \text{ kW}$$

$$\Delta kW_{PJM} = 295 / 570 * 0.466$$

$$= 0.241 \text{ kW}$$

**NATURAL GAS SAVINGS**

If Natural Gas heating:

$$\Delta Therms = (((1/R\_old - 1/R\_wall) * A\_wall * (1-Framing\_factor) + (1/R\_old - 1/R\_attic) * A\_attic * (1-Framing\_factor/2)) * 24 * HDD) / (\eta Heat * 100,067 \text{ Btu/therm})$$

Where:

HDD = Heating Degree Days

= Dependent on location[990]:

| Climate Zone (City based upon) | HDD 60 |
|---|---|
| 1 (Rockford) | 5,352 |
| 2 (Chicago) | 5,113 |
| 3 (Springfield) | 4,379 |
| 4 (Belleville) | 3,378 |
| 5 (Marion) | 3,438 |
| Weighted Average[991] | 4,860 |

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

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average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[990] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[991] Weighted based on number of occupied residential housing units in each zone.

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= Actual[992]. If unknown assume 70% [993].

Other factors as defined above

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For example, a single family home in Chicago with 990 ft$^2$ of R-5 walls insulated to R-11 and 700 ft$^2$ of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66%:

ΔTherms = ΔkWh_cooling + ΔkWh_heating

= (((1/5 - 1/11) * 990 * (1-0.15) + (1/5 - 1/38) * 700 * (1-0.15/2)) * 24 * 5113) / (0.66 * 100,067)

= 380 therms

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**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: RS-SHL-AINS-V01-060112**

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[992] Ideally, the System Efficiency should 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.

[993] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls)). In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: (0.24*0.92) + (0.76*0.8) * (1-0.15) =  0.70

# 8   C&I Custom Protocols

These protocols define the requirements for analyzing and documenting energy efficiency measures. There are two types of protocols, protocols that allow for expanded use of the commercial and industrial  measures defined in the statewide TRM (expansion) and those that address measures that are not covered by other analysis methodologies in the statewide TRM (custom measure analysis).

The following protocols have been defined for expansion measures:

> C&I Measure Expansion Protocol
> C&I Measure Expansion Template

## 8.1   C&I Measure Custom Value Protocol

This protocol defines the requirements for capturing custom variables stated in the commercial and industrial prescriptive measure defined in this statewide TRM.  This protocol is to be used when a variable in a measure formula can be replaced by a verifiable and documented value that is not presented in the TRM.  This protocol assumes that the algorithms presented in the measure are used as stated and only allows changes to certain variable values and is not a replacement algorithm for the measure.  If a new algorithm is required for the measure in question, a custom measure protocol can be employed, if appropriate, or the measure can be entered into the defined change/update process for further consideration as to the measure change or addition to the next statewide TRM revision.  Implementers can use custom measures outside of change/update process but they may be at risk for savings values until such time as the measure is approved and incorporated into the TRM.

This protocol is intended to address the energy impacts of the incremental energy efficiency improvements over what would have been installed as per applicable federal/state/local codes or standard industry practice and allow the program implementer some flexibility in entering custom values into defined energy savings algorithms.  The protocol allows this flexibility only on certain measures and on certain values within those measures.

### 8.1.1   Custom Variables

The following table defines which measures this custom approach can be applied to and further, what variables can be adjusted.  This table does not include variables that require actually installed numbers that are collected from the customer, but maps those values where a default value is provided that can be replaced with a custom value.  Also indicated is the type of validation required to update a custom figure.

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.2.3 | Commercial Steam Cooker | $HOURS_{day}$ | Average Dailey Operation (hours) | Customer input or Measured value | |
| | | F | Food cooked per day (lb) | Customer input or Measured value | |
| | | $Days_{Year}$ | Annual Days of Operation (days) | Customer input or Measured value | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.2.5 | ENERGY STAR Convection Oven | HOURSday | Average Dailey Operation (hours) | Customer input or Measured value | |
| | | Days | Annual Days of Operation (days | Customer input or Measured value | |
| | | LB | Food cooked per day (lb) | Customer input or Measured value | |
| | | EffENERGYSTAR | Cooking Efficiency ENERGY STAR | From ENERGY STAR product data | |
| | | EffBase | Cooking Efficiency Baseline | Customer input or Measured value | |
| | | PCENERGYSTAR | Production Capacity ENERGY STAR (lbs/hr) | Customer input or Measured value | |
| | | PCBase | Production Capacity base (lbs/hr) | Customer input or Measured value | |
| | | PPreheatNumberENERGYSTAR | Number of preheates per day ENERGY STAR | From ENERGY STAR product data | |
| | | PreheatNumberbase | Number of preheats per day Base | Customer input or Measured value | |
| | | PreheatTimeENERGYSTAR | preheat length ENERGY STAR, min | From ENERGY STAR product data | |
| | | PreheatTimeBase | preheat length base, min | Customer input or Measured value | |
| | | PreheatRateENERGYSTAR | preheat energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | |
| | | PreheatRateBase | preheat energy rate baseline, btu/h | Customer input or Measured value | |
| | | IdleENERGYSTAR | Idle energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | |
| | | IdleBase | Idle energy rate baseline, btu/h | Customer input or Measured value | |
| | | IdleBaseTime | BASE Idle Time, hours | Customer input or Measured value | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.2.5 | ENERGY STAR Convection Oven | HOURSday | Average Dailey Operation (hours) | Customer input or Measured value | |
| | | Days | Annual Days of Operation (days | Customer input or Measured value | |
| | | LB | Food cooked per day (lb) | Customer input or Measured value | |
| | | EffENERGYSTAR | Cooking Efficiency ENERGY STAR | From ENERGY STAR product data | |
| | | EffBase | Cooking Efficiency Baseline | Customer input or Measured value | |
| | | PCENERGYSTAR | Production Capacity ENERGY STAR (lbs/hr) | Customer input or Measured value | |
| | | PCBase | Production Capacity base (lbs/hr) | Customer input or Measured value | |
| | | PPreheatNumberENERGYSTAR | Number of preheates per day ENERGY STAR | From ENERGY STAR product data | |
| | | PreheatNumberbase | Number of preheates per day Base | Customer input or Measured value | |
| | | PreheatTimeENERGYSTAR | preheat length ENERGY STAR, min | From ENERGY STAR product data | |
| | | PreheatTimeBase | preheat length base, min | Customer input or Measured value | |
| | | PreheatRateENERGYSTAR | preheat energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | |
| | | PreheatRateBase | preheat energy rate baseline, btu/h | Customer input or Measured value | |
| | | IdleENERGYSTAR | Idle energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | |
| | | IdleBase | Idle energy rate baseline, btu/h | Customer input or Measured value | |
| | | IdleBaseTime | BASE Idle Time, hours | Customer input or Measured value | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.2.7 | ENERGY STAR Fryer | HOURSday | Average Dailey Operation (hours) | Customer input or Measured value | |
| | | Days | Annual Days of Operation (days | Customer input or Measured value | |
| | | LB | Food cooked per day (lb) | Customer input or Measured value | |
| | | EffENERGYSTAR | Cooking Efficiency ENERGY STAR | From ENERGY STAR product data | |
| | | EffBase | Cooking Efficiency Baseline | Customer input or Measured value | |
| | | PCENERGYSTAR | Production Capacity ENERGY STAR (lbs/hr) | Customer input or Measured value | |
| | | PCBase | Production Capacity base (lbs/hr) | Customer input or Measured value | |
| | | PPreheatNumberENERGYSTAR | Number of preheates per day ENERGY STAR | From ENERGY STAR product data | |
| | | PreheatNumberbase | Number of preheates per day Base | Customer input or Measured value | |
| | | PreheatTimeENERGYSTAR | preheat length ENERGY STAR, min | From ENERGY STAR product data | |
| | | PreheatTimeBase | preheat length base, min | Customer input or Measured value | |
| | | PreheatRateENERGYSTAR | preheat energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | |
| | | PreheatRateBase | preheat energy rate baseline, btu/h | Customer input or Measured value | |
| | | IdleENERGYSTAR | Idle energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | |
| | | IdleBase | Idle energy rate baseline, btu/h | Customer input or Measured value | |
| | | IdleBaseTime | BASE Idle Time, hours | Customer input or Measured value | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.2.7 | ENERGY STAR Fryer | HOURSday | Average Dailey Operation (hours) | Customer input or Measured value | Electric and Gas |
| | | Days | Annual Days of Operation (days | Customer input or Measured value | Electric and Gas |
| | | LB | Food cooked per day (lb) | Customer input or Measured value | Electric and Gas |
| | | Width | Griddle Width, ft | Customer input or Measured value | Electric and Gas |
| | | Depth | Griddle Depth, ft | Customer input or Measured value | Electric and Gas |
| | | EffENERGYSTAR | Cooking Efficiency ENERGY STAR | From ENERGY STAR product data | Electric and Gas |
| | | EffBase | Cooking Efficiency Baseline | Customer input or Measured value | Electric and Gas |
| | | PCENERGYSTAR | Production Capacity ENERGY STAR (lbs/hr) | Customer input or Measured value | Electric and Gas |
| | | PCBase | Production Capacity base (lbs/hr) | Customer input or Measured value | Electric and Gas |
| | | PPreheatNumberENERGYSTAR | Number of preheates per day ENERGY STAR | From ENERGY STAR product data | Electric and Gas |
| | | PreheatNumberbase | Number of preheates per day Base | Customer input or Measured value | Electric and Gas |
| | | PreheatTimeENERGYSTAR | preheat length ENERGY STAR, min | From ENERGY STAR product data | Electric and Gas |
| | | PreheatTimeBase | preheat length base, min | Customer input or Measured value | Electric and Gas |
| | | PreheatRateENERGYSTAR | preheat energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | Electric and Gas |
| | | PreheatRateBase | preheat energy rate baseline, btu/h | Customer input or Measured value | Electric and Gas |
| | | IdleENERGYSTAR | Idle energy rate ENERGY STAR, btu/h | From ENERGY STAR product data | Electric and Gas |
| | | IdleBase | Idle energy rate baseline, btu/h | Customer input or Measured value | Electric and Gas |
| | | IdleBaseTime | BASE Idle Time, hours | Customer input or Measured value | Electric and Gas |
| 6.2.9 ENERGY STAR | ENERGY STAR Hot Food Holding Cabinet | PowerBaseline | Baseline power of cabinet, Watts | | |
| | | PowerENERGYSTAR | cabinet, Watts | From ENERGY STAR product data | |
| | | HOURSday | Average Dailey Operation (hours) | Customer input or Measured value | |
| | | Days | Annual Days of Operation (days | Customer input or Measured value | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.3.1 | High Efficiency Pre-Rinse Spray Valve | Tout | Outlet Water Temperature | Customer input or Measured value | |
| | | Tin | Inlet Water Temperature | Customer input or Measured value | |
| | | EFF | Efficiency of water heater supplying hot water | Customer input or Measured value or Manufacturer specification | This applicable to both the gas efficiency and the electric efficiency |
| | | FLObase | Base case flow in gallons per minute | Customer input or Measured value or Manufacturer specification | |
| | | FLOeff | Efficient case flow in gallons per minute | Customer input or Measured value or Manufacturer specification | |
| | | $HOURS_{day}$ | Hours or use per day | Customer input or Measured value | |
| | | $Days_{Year}$ | Days of use per year | Customer input or Measured value | |
| 6.3.2 | Low Flow Faucet Aerators | NOPF | Number of occupants per faucet | Customer input | |
| | | GPM_base | Average flow rate, in gallons per minute, of the baseline faucet "as-used" | Documented value based on study or report | |
| | | GPM_low | Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used | Documented value based on study or report | |
| | | L_base | Average baseline length faucet use per capita for all faucets in minutes | Documented value based on study or report | |
| | | L_low | Average retrofit length faucet use per capita for all faucets in minutes | Documented value based on study or report | |
| 6.3.3 | Low Showerheads | GPM_base | Average flow rate, in gallons per minute, of the baseline faucet "as-used" | Documented flow rate from installed equipment | |
| | | NSPF | Number of showers per faucets | Customer input | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.3.4 | Tankless Water Heater | Wgal | Annual Water use for equipment | Customer input or measured value | |
| | | Tout | Outlet Water Temperature | Customer input or measured value | |
| | | Tin | Inlet Water Temperature | Customer input or measured value | |
| | | SL | Stand-by Loss in Base Case Btu/hr | Customer input or measured value | |
| | | Effee | Rated Efficiency of water Heater | Customer input or documented value based on study or report | |
| | | Tank Volume | Tank Volume | Customer input or documented value based on study or report | |
| 6.4.2 | Space Boiler Tune-up | Ngi | Boiler gas input size | Customer input or Measured value | |
| | | SF | Savings Factor | Customer input or Measured value | |
| | | Effpre | Boiler Efficiency before Tune-up | Customer input or Measured value | |
| 6.4.3 | Process Boiler Tune-up | Ngi | Boiler gas input size | Customer input or Measured value | |
| | | UF | Utilization Factor | Customer input or Measured value | |
| | | Effpre | Boiler Combustion Efficiency before Tune-up | Customer input or Measured value | |
| | | $Eff_{measured}$ | Boiler Combustion Efficiency before Tune-up | Customer input or Measured value | |
| 6.4.4 | Boiler Lockout/Reset Controls | Binput | Boiler Input Capacity | Customer input or measured value | |
| | | SF | Savings Factor | Customer input or Measured value | |
| | | Effpre | Boiler Efficiency | Customer input or Measured value | |
| 6.4.11 | High Efficiency Boiler | Capacity | Nominal Heating Capacity Boiler Size | Customer input or Measured value | |
| | | AFUE(base) | Efficient Furnace Annual Fuel Utilization Efficiency Rating | Customer input or Measured value | |
| | | AFUE(eff) | Efficient Furnace Annual Fuel Utilization Efficiency Rating | Customer input or Measured value | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.4.12 | High Efficiency Furnace | Capacity | Nominal Furnace input capacity | Customer input or Measured value | |
| | | AFUE(base) | Efficient Furnace Annual Fuel Utilization Efficiency Rating | Customer input or Measured value | |
| | | AFUE(eff) | Efficient Furnace Annual Fuel Utilization Efficiency Rating | Customer input or Measured value | |
| 6.4.15 | Steam Trap Replacement or Repair | B | Boiler Efficiency | Customer input or measured value | |
| | | L | Leaking and blow-thru percentage | Customer input or documented value based on study or report | |
| 6.4.16 | VSD for HVAC | HP | Motor HP | Customer input or measured value | |
| | | Load Factor | Motor Load Factor | | |
| | | Hours | Actual hours for equipment operations | Customer input or Measured value | |
| | | ESF | VDS Energy Savings Factors | Custom calculated values | |
| | | CF | Coincidence factor | Custom calculated values | |
| 6.5.3 | HPT8 Lighting | $Watts_{base}$ | Base Wattage | Customer input or measured value | This will allow for reduced wattage applications |
| | | $Watts_{EE}$ | Efficiency Wattage | Customer input or measured value | This will allow for reduced wattage applications |
| | | Hours | Average use hours | Customer input or documented value based on study or report | |

| Measure Number | Measure Title | Adjustable Variable | Adjustable Variable Description | Documentation | Notes |
|---|---|---|---|---|---|
| 6.5.4 | T5 Lighting | $Watts_{base}$ | Base Wattage | Customer input or measured value | This will allow for reduced wattage applications |
| | | $Watts_{EE}$ | Efficiency Wattage | Customer input or measured value | This will allow for reduced wattage applications |
| | | Hours | Average use hours | Customer input or documented value based on study or report | |
| 6.5.5 | Lighting Controls | $KW_{connected}$ | Total Connected kW load | Customer input or measured value | |
| | | Hours | Hours of use | Customer input or documented value based on study or report | |
| | | ESF | Energy Savings Factor | Customer input or documented value based on study or report | |
| 6.5.6 | Lighting Power Density Reduction | $WSF_{effic}$ | The actual installed lighting watts per square foot or linear foot | Customer input | |
| | | SF | square footage of the building area applicable to the lighting design | Customer input | |
| | | Hours | Hours of use | Customer input | |

## 8.1.2   Documentation and Metering

Documentation and metering of custom projects are essential to developing reliable energy savings and Coincident Electrical Demand reduction claims.[994]   The following guidelines support the accurate estimation of energy and demand savings.

### DATA AND METERING

Document how the data will be collected and utilized in the savings analysis in a Measurement and Verification (M&V) Plan. The Custom Analysis Template can be used as a tool to document the M&V plan and analysis[995]. Metering for Equipment Replacement projects is typically conducted post-installation to establish the Coincidence Factor, operating hours and Load Factor.  Where measures include a control component, metering of these factors in the baseline condition is necessary to accurately establish the baseline.

### INTERVAL AND UTILITY DATA

Utility interval data is typically not useful in analyzing equipment replacement projects because the baseline condition is not represented in the utility billing data.

For completed mercantile projects in existing facilities, project documentation shall include two - three years of utility billing information from years PRIOR to measure installation and up to three years of utility data post installation in accordance with PUCO requirements.

### METER DATA

Accuracy of all metering and measurement equipment shall be documented in the M&V Plan.

Document the metering methods including equipment type, location of metering equipment, and equipment set up process, as well as metering duration and timeframe for which data was collected.  Capture all variables that affect energy use of the measures during the metering period as outlined in Section 3.  Describe how the metered data, including timeframe and operational factors at the time of metering, relate to the operational conditions that occur over the course of a year.  Provide photographs of meter installation and clear documentation of meter numbers and the associated equipment names of the equipment being metered in the project documentation. Meter data files should clearly identify the equipment to which the meter data applies.

For variable loads, three-phase power data loggers shall be used to collect electrical power data for systems and subsystems of the custom measure996.  For constant loads, accurate spot reading of the load coupled with runtime logging is an acceptable metering methodology.  Temperature and time of use loggers can be used to meter proxy variables, equipment status, and runtimes.  Ensure that proxy variable metering yields calculated kW values in compliance with PJM997  Section 11 requirements.

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[994] Parlin, Kathryn, et. al. (August, 2009 IEPEC) "Demand Reduction in the Forward Capacity Market, Verifying the Efficiency Power Plant"

[995] IPMVP, Volume III, Part I, January 2006, Chapter 3, page 7 through 10, and PJM Manual 18B, April 2009, section 2, page 10 through 14

[996] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Section 11, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

[997] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Section 11, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

Three-phase power data loggers shall record: amperage, voltage, power factor, and kW on all phases as well as the totals for each variable. All electrical power metering shall adequately account for harmonics[998]. Logging shall capture equipment load under representative operating conditions. The time period of logging shall be adequate to represent variations in load that will occur over the analysis period. Where feasible, use metering or data logging to capture variables affecting load during the metering period. Where variables cannot be captured using meters or data loggers, institute and clearly document a method for accurately capturing variables, validating non-metered data, and aligning it with metered data. Metering periods shall be a minimum of one week, including a weekend, for constant load equipment and at least two weeks, including weekends, for variable load equipment, but as noted above, must be long enough to capture representative variations in load expected over the entire analysis period.

Integrating/averaging three-phase power meters are desirable. Power metering accuracy requirements are outlined in PJM Manual 18B[999] and RLW Analytics Review of ISO New England Measurement and Verification Equipment Requirements[1000]. Metering intervals shall be the smallest time interval that will permit acquisition of data over the minimum required metering period. For short-cycling or modulating systems, 30-second or 1-minute data intervals are preferred, with a maximum recommended interval of 5 minutes. For constant load systems, the metering interval can be longer. No metering interval should exceed 15 minutes. Clearly document how meter intervals and meter periods capture the expected load variations for the project.

Meters and data loggers shall be synchronized to the NIST time clock, and differences between the time at the facility and the NIST time setting should be noted when the meters are installed.

### DDC/PLC MONITOR DATA

Use of DDC and PLC monitoring software trends in the analysis is acceptable provided that the sensors are calibrated on site using calibrated test instruments and the results documented by the energy analyst before the metering period commences. Review and submission of annual equipment calibration records for DDC sensors and metering equipment is a less desirable, but acceptable alternative to calibration of DDC equipment as part of the project. Timestamps for trends should be set up to coincide with those of any concurrently deployed data loggers to enable accurate data analysis.

## 8.1.3   General Procedures for Data Analysis

### DATA CLEANING

It is usually necessary to 'clean' the raw data before proceeding with the analysis. The following data cleaning tasks are typically required.

Ensure that the timestamps match between datasets (e.g. for concurrent kW and temperature datasets), and that any gaps in the data which are not representative of typical operation have been addressed by interpolation or

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[998] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Section 11, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

[999] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

[1000] RLW Analytics, Review of ISO New England Measurement and Verification Equipment Requirements, Final Report, April 24, 2008 Prepared for: Northeast Energy Efficiency Partnerships' Evaluation and State Program Working Group; RLW Metering Report.pdf

other means. Interpolated or derived data shall be flagged, and the method used to fill in data gaps shall be described.

Note that in preparing the data for use in the 8760 analysis, there will likely be blocks of time during the metering period that will be analyzed differently. For example, during regular business hours a load may be temperature dependent and the data will be analyzed using a regression analysis of kW vs. outdoor air temperature; whereas the same piece of equipment on the weekend may have a constant standby load and is thus schedule driven and non-temperature dependent on the weekends. Different blocks of the 8760 hours in a year will be populated from the separate analyses of the distinct blocks of meter data.

ANNUALIZATION AND ANALYSIS APPROACH

The recommended approach to annualization of meter data and savings calculations is an 8760 analysis[1001]. This approach inherently captures seasonality and peak period variability on an hourly basis and is therefore more accurate than other traditional methods such as binned analysis.

Typical approaches to analyzing custom measures include:

- Demand vs. temperature analysis for temperature dependent measures.
- Daily operating profiles for schedule-driven measures
- Cyclical production profiles for production-related measures

These methods should address part load performance, and may employ different metrics such as:

- Demand vs. percent capacity
- Demand/Ton vs. percent capacity
- Demand vs. hours
- Demand per ton, pound, cubic foot or quantity

## 8.1.4 Reporting

The following metrics and details shall be reported:

- All information required in this protocol
- M&V Plan/Analysis Template
- Regression $R^2$ values for fits of demand vs. proxy variables.
- Cleaned meter data (raw data shall be included as an appendix) clearly indicating which data was used in the savings analysis

## 8.1.5 C&I Measure Custom Value Collection Template

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[1001] Patil, Yogesh, et. al. (Aug, 2009) "Taking Engineering Savings to the Next Level, presented at IEPEC 2009; http://www.ers-inc.com/images/articles/Papers/takingsavingstonextlevel.pdf

### SECTION A. MEASURE CUSTOM VALUE INFORMATION

Note:  If implementer already has a form to capture this type of data, it may be used in place of this form.

Project Name

TRM Measure Name/Number:

Date

**Table 5 – Custom Variables**

| Customized Number | Variable Name | Variable Value | Source of Custom Value |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| | Recaclucated Measure Savings (using meaures Algoritym) | | |

### SECTION B.  METERING AND DATA COLLECTION, IF APPLICABLE

If custom value is provided by customer or site observed data (such as an inlet temperature gauge); this section is not required.  If metering data will provide the custom value, this section should be completed.  Upon completion of metering and analysis, update this document to reflect actual findings and final analysis approach.

Metering Approach

Discuss the approach to energy and demand metering including load shape and coincident demand determination from meter data. Describe when metering occurred and how it is deemed to represent the post installation, annual operating conditions. Provide justification and supporting documentation for all assumptions and metering techniques.

Data Collection Methodology

Indicate the primary method(s) used to obtain the data needed for TRM Section 2 equations.

Power Metering:

　　　　Data Logging:

　　　　DDC/PLC:

　　　　Interval Data:

　　　　Customer Interview:

　　　　Other (describe):

**Table 6 - Project Data Acquisition**

| | | | |
|---|---|---|---|
| **Data Collection Method [1]** | | | |
| **When data was collected (pre/post) installation** | | | |
| **Measure(s) Affected** | | | |
| **Equipment monitored** | | | |
| **Parameter measured** | | | |
| **Measurement equipment** | | | |
| **Observation frequency** | | | |
| **Metering duration** | | | |
| **Sensor type** | | | |
| **Accuracy of sensors** | | | |
| **Overall accuracy of meter system** | | | |
| **Verify whether meter was synchronized to NIST** | | | |

[1] Indicate data collection method(s) across the top; not all rows apply for all data collection methods. Duplicate table as needed to capture all data collection methods used for the measures associated with this project

Equipment Calibration

Discuss calibration procedures used to maintain calibration of any metering and/or logging equipment used in the metering process. Where DDC and/or PLC devices and systems were used to obtain project data, describe the calibration protocol and document the results.

Data Cleaning and Data Reduction

Discuss steps taken to align timestamps, fill gaps in raw data and address other data issues such as inaccurate or inconclusive readings. Depending on the level of verification required by the program, include raw, cleaned, and analyzed datasets as appropriate

**SIGNATURE OF ENERGY ANALYST**

_____

**DATE OF SUBMITTED REPORT**

_____